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Vol. 7 No. 84 (New Series)

DECEMBER, 1961

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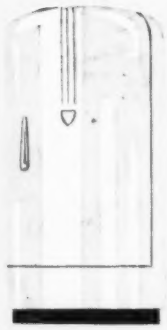

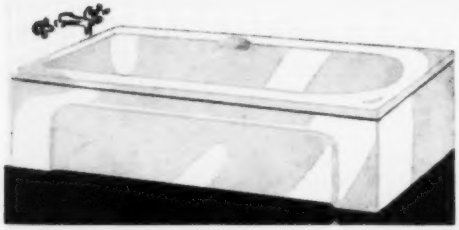

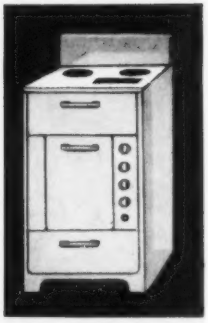

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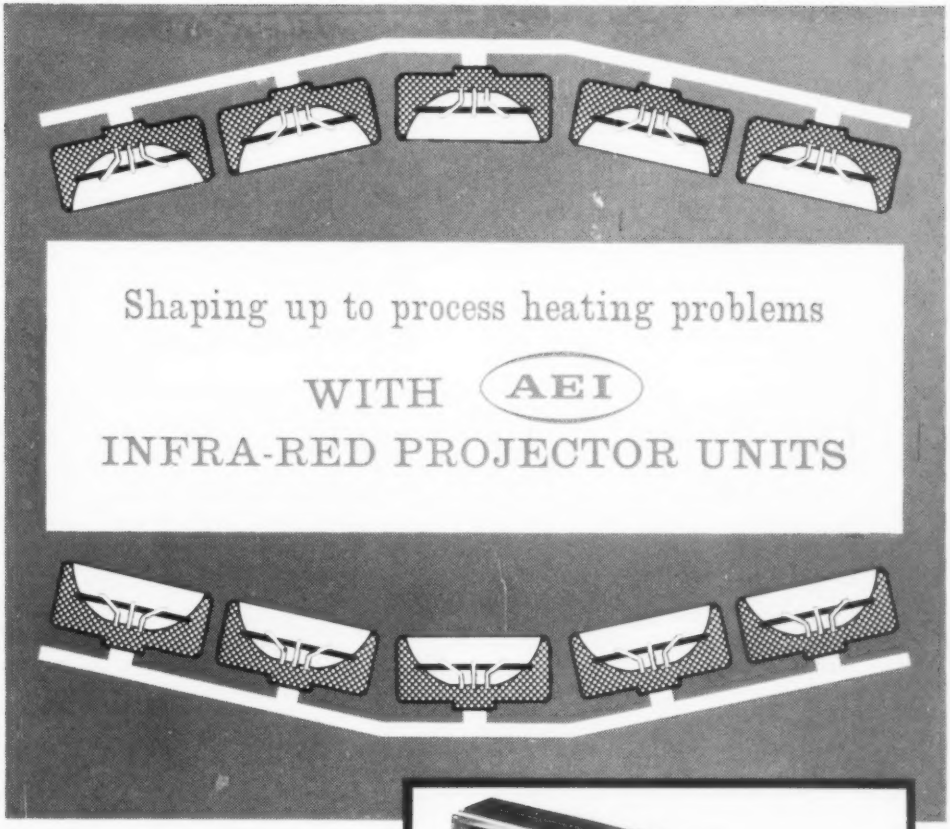

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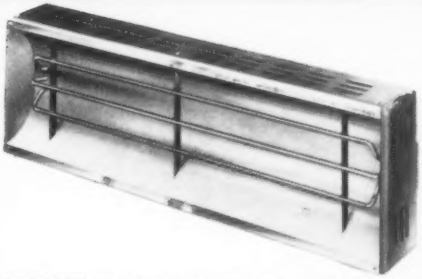

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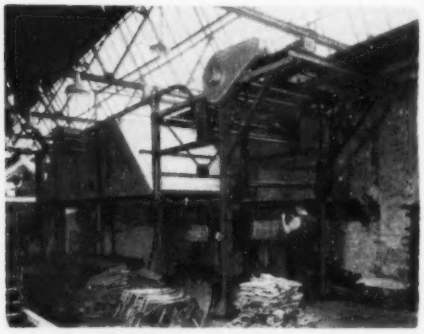

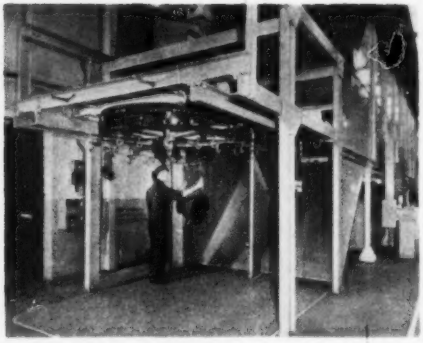

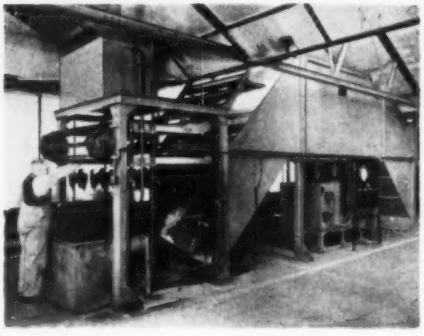

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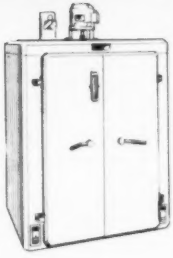

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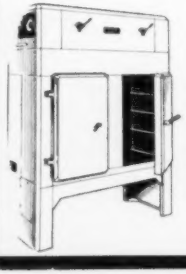

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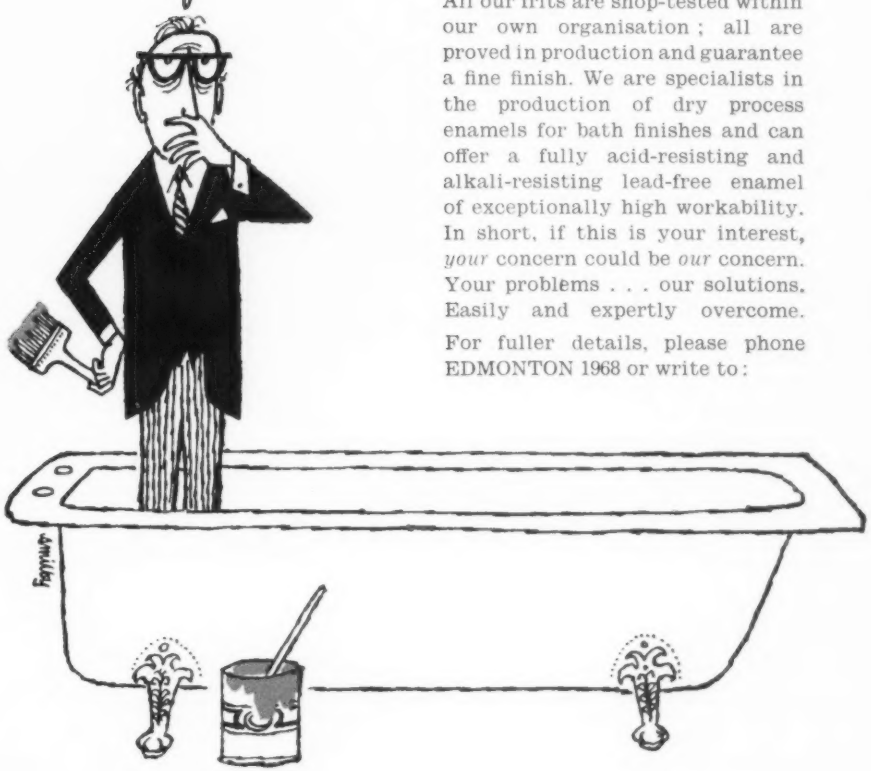

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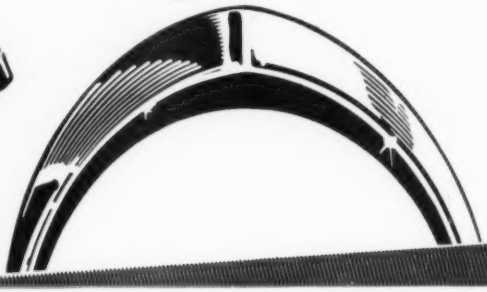

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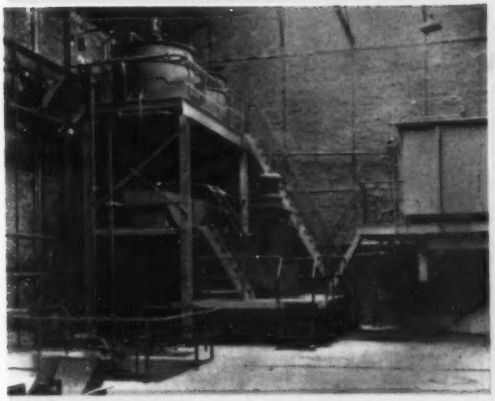

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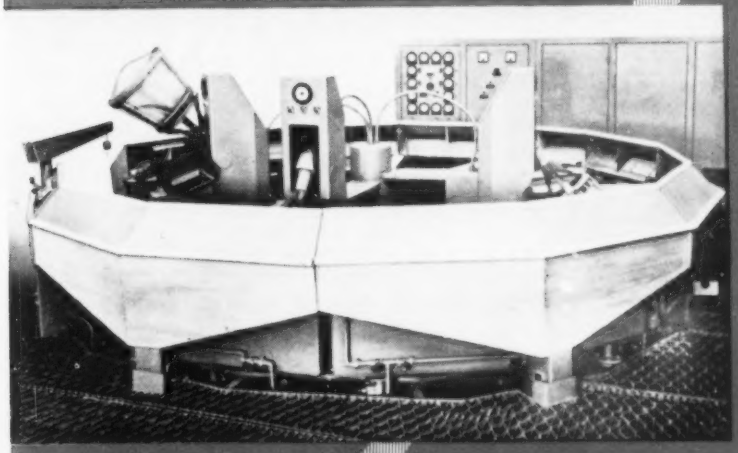

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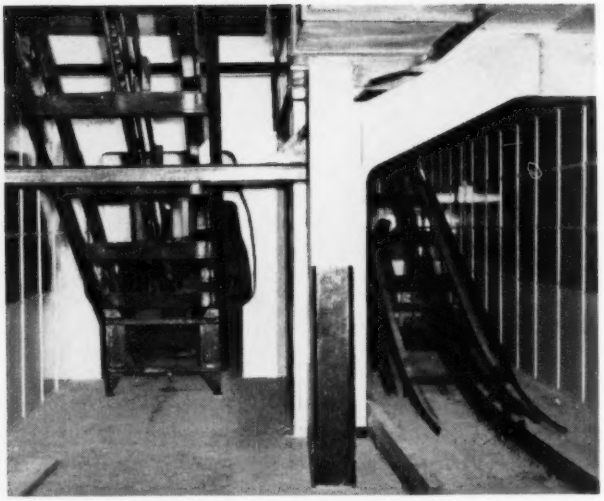

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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

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Season's Greetings

The Editor and Staff of " Metal Finishing Journal " extend to all readers, advertisers, contributors and other friends at home and overseas, sincere good wishes for their happiness in the Christmas season and greater prosperity in the New Year.

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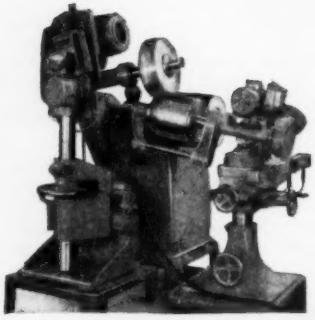

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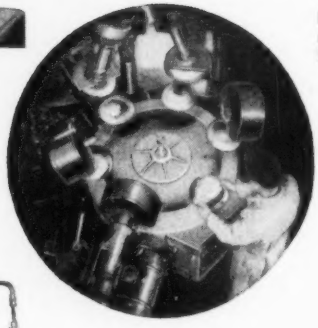

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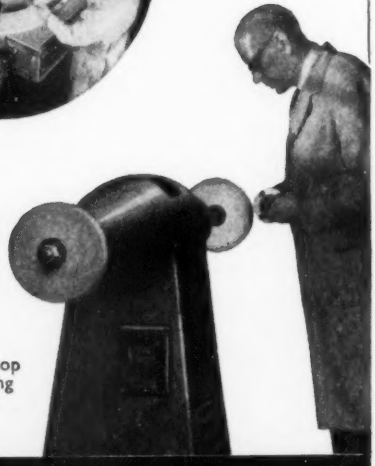

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THE UPWARD PATH

AS a material of construction aluminium has a number of properties which commend themselves and of which advantage has been taken in a very wide range of manufactured products. As a metal it is available in a number of grades of purity and it forms the basis of a great variety of alloys offering the whole gamut of response to heat treatment and cold working and lending themselves to fabrication by most known processes.

As a basis for finishing however, aluminium and its alloys exhibit bilateral tendencies. Most of the finishes commonly applied to its giant competitor mild steel, such as paint, electrodeposited coatings and vitreous enamels, can only be applied to aluminium by the utilization of special pre-treatment processes or of modifications to standard formulations. On the other hand, the light alloys have the virtually unique facility of lending themselves to the application of a finish coating generated from their own tissue.

In view of the versatility and ubiquity of applications of aluminium and its alloys and the high reflectivity and other attractive features which can be achieved by anodic processing, it is only to be expected that papers relating to the anodizing process should appear with fairly regular frequency in the technical literature. Indeed it is apparent that the process is not as simple as a superficial acquaintance which its requirements would lead one to suppose.

Nevertheless it is worthy of remark that in the past three months there have been three important and well attended meetings organized for the sole purpose of discussing the science and technology of the anodizing of aluminium. We have been pleased to be able to bring to our readers an informed critical survey of the proceedings at each of these meetings, specially prepared for METAL FINISHING JOURNAL by expert contributors. The first of these reports dealing with the International Conference on the Surface Treatment of Aluminium held in Milan in October, was published in our issue of last month. The second, covering the Conference on Anodizing organized at Nottingham University by the Aluminium Development Association last September, appears in the current issue, while the third, the International Conference on Metal Finishing Standards, held in October in Turin, will be reviewed in our pages next month.

As long ago as June 1955 we stated on this page that while "interest (in brightened and anodized aluminium) has been stimulated by current shortages of nickel . . . it would be unfair to regard the potentialities of brightened aluminium to exist solely in its application as a substitute material in time of shortage. Developments . . . show only too plainly that lightness, high reflectivity, ease of processing, and good resistance to corrosion can claim serious attention in their own right." While this statement was undoubtedly true seven years ago, the rate at which anodized aluminium has captured markets from nickel-chromium plating and other finishes in the intervening period, albeit steady, has not been spectacularly fast. It is to be expected therefore that those responsible for the promotion of the sale of aluminium as well as those who apply anodic finishes to it will be encouraged by the statement made by an eminent member of the motor-car industry at the Nottingham Conference to the effect that anodized aluminium can now be regarded as an accepted finish in the motor-car industry for trim applications and that it should be judged on its own merits and not necessarily in relation to other finishes hitherto popular.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

JOB FOR SOMEONE

LOOKING around the Factory Equipment Exhibition, one could not fail to be impressed by the many ingenious devices which are constantly being developed. Often they are basically simple in conception, but can nevertheless go a long way towards making production easier in factories, lowering costs, and improving safety.

The trouble is that, as often as not, the need for the product seldom coincides with the time when it is first noticed either at an Exhibition such as this, or in the trade press; and in due course when it is wanted one has forgotten the reference or the name of the maker, and the equipment cannot be located.

A notable contribution towards the solution of this problem in one industry has been made by an information service which maintains indexed files of catalogues of building products in the offices of architects and construction engineers. They are kept constantly up to date and have proved of inestimable value to all concerned, as is evidenced by the success of the firm which initiated the service a few years ago.

There is scope here for someone with enterprise to start a similar service for the works manager.

PENALTY AREAS

THE fact that the builders of the new U.S. Embassy in London are having to institute expensive claim proceedings in Washington to try to recover the outstanding half of their bill, illustrates the pitfalls awaiting those who accept penalty clauses in their contracts. The building was late in completion, allegedly because of delays in getting necessary drawings from the U.S.A., while the fact that it was signed in the old Embassy building (and therefore on U.S. territory) takes the contract out of British jurisdiction.

In this country penalty clauses for delivery dates are seldom asked for, and are rarely acceptable to suppliers. Abroad, however, and particularly in the U.S.A. and Eastern Europe, they are much more general, and it seems likely that British manufacturers will have to get more used to them in time. They are contentious documents which can give rise to endless arguments and are therefore good meat for the lawyers. Even when they are not strictly enforced by the buyer they do, however, have a psychological effect on the supplier, whose delivery dates in this country are apt to be based on a rough guess as to what his competitors are offering rather than on a genuine assessment of his own capacity. Likewise, only a very naive customer will take any delivery promises he is given too seriously.

The inability on the part of certain manufacturers to maintain delivery appears to be pathological, and has little to do with pressure of business; this is shown by the fact that they are just as likely to be late when things are quiet as when their order books are full.

CASTING THE NET

JOBBING work in the metal-finishing trade has always been regarded as something in the nature of a parochial business. Customers are usually located within a daily delivery radius—something like a milk round, in fact. There is, however, some tendency now to go further afield, and a few of the larger platers are now regularly doing work for firms a hundred miles or more away.

But need it stop there?

If the Russians, for example, have found it worth while to send 60,000 tons of steel to Glasgow for cold reduction at the Colville Mills, might they not likewise take advantage of our current surplus plating capacity? We may yet see bumpers for the Moskowitch plated in Birmingham, and Tatra radiator grills in Oxford.

SOME DRAUGHT!

"OWING to the amount of air drawn into the vat by the exhaust system, high current densities are permissible in the suspension wires because of the cooling effect of the air. Thus a wire in the vat will easily carry current that would raise it to red heat in still air."

From an article on Chromium Plating in Newnes' Engineers' Reference Book (9th Edition) 1960.

SEVEN YEARS HARD

WHICH brings me to the end of the column for another year. To all whose ideas and experience have been distilled into the essence of "Talking Points," to those with whom I have mildly disagreed from time to time, and to the patient readers who have found pleasure or exasperation in reading these jottings over the past seven years, I send the ancient but ever-fresh greeting: "A Merry Xmas and a Happy New Year!"

STRESSES IN HARD CHROMIUM AND HEAVY NICKEL DEPOSITS AND THEIR INFLUENCE ON THE FATIGUE STRENGTH OF THE BASIS METAL*

by R. A. F. HAMMOND† O.B.E., B.Sc., A.R.C.S., F.R.I.C.

(One of the lectures presented at the Borough Polytechnic, London, at a One-day Symposium on "Internal Stresses in Electrolytically Produced Coatings and their Influence on the Properties of the Basis Metal" and published by permission of the Principal.)

Introduction

BEFORE considering the effect of internal stress in an electrodeposit on the fatigue strength of a plated component in detail it will be helpful to consider briefly the mechanism by which fatigue failure occurs. When a metal is subjected to fluctuating tensile stress above a critical value, after a certain number of stress cycles, usually a large number, minute cracks form at the location of maximum stress, usually at the surface, and these, once formed, rapidly propagate in a trans-crystalline manner leading to fatigue fracture of the metal. The maximum fluctuating tensile stress which the metal can sustain indefinitely without fracture is known as the fatigue limit of the metal. In the case of steels, the fatigue limit is approximately one half of the tensile strength.

For steels most commonly in use, the fatigue strength exceeds the fatigue strength of the applied coating, including for example electrodeposited chromium or nickel. It follows that fatigue cracks will develop in the coating at a lower level of applied tensile stress than the fatigue limit of the steel, especially since the coating is on the surface of the component where the stress is usually greatest. Such cracks, by acting as a notch, will give rise to increased stress concentration at the root of the crack so that, locally, the steel will be subjected to a higher level of tensile stress than the applied stress and when the local stress concentration at the interface reaches the fatigue limit of the steel, the crack in the coating will propagate into the steel and fatigue fracture will follow at some value less than the fatigue strength of the steel.

It will be apparent that the course of events will be modified by any internal stress in the electrodeposited coating. Thus any tensile stress in the electrodeposit will augment the applied stress and the coating will develop fatigue cracks at a lower applied stress level than its true fatigue strength. Conversely, if the deposit possesses internal compressive stress this will tend to neutralize the applied tensile stress and the deposit will sustain a higher applied stress than its nominal fatigue strength without cracking.

It is clear, therefore, that the magnitude and direction of the internal stress in the electrodeposit will be an important controlling influence on the fatigue strength of the plated metal.

Barklie and Davies[1] first suggested that the reduction in fatigue strength of steel which they observed on nickel plating was due to the internal tensile stress in the deposit and showed that when the stress was reduced by using superimposed a.c. during deposition, the loss in fatigue limit was also diminished. They also showed that interposing a thin electrodeposit of lead between the nickel and the steel improved the fatigue strength by preventing propagation of the fatigue cracks in the nickel.

With increasing use of electrodeposition in the aircraft industry, particularly of chromium or nickel plating for repair or hard-surfacing, much effort has been devoted in recent years to determining the effect of such processes on the fatigue limit of steel and much of this has been concentrated on determining the effect of internal stress in the deposits.

Chromium (unbaked deposits)

The internal stress of chromium deposits can vary widely according to the temperature of deposition from slightly compressive at 40°C. to highly tensile *e.g.* 30 tons per sq. in at 85°C. for chromium deposited from the standard hard chromium solution (250 gm. per l. CrO_3 2.5 gm. per l. H_2SO_4.

*Crown copyright is reserved in respect of Figs. 1, 2, 3, 4, 5, 7, 8, 9, 10, 11 and of Table I.

†War Office, A.R.D.E., Fort Halstead.

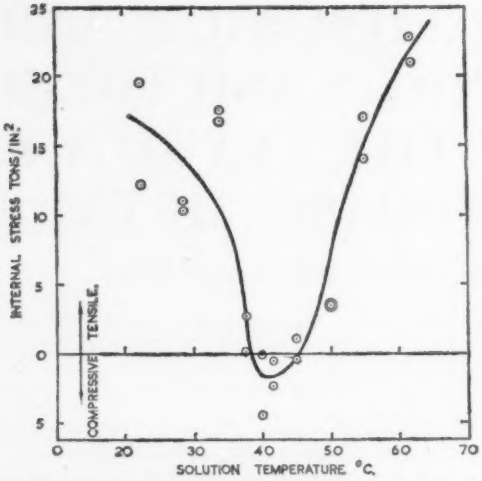


Fig. 1.—Effect of plating-solution temperature on the internal stress of the chromium deposits (Solution CrO_3 250 gm. per l., H_2SO_4 2.5 gm. per l., current density 200 amps per sq. ft.

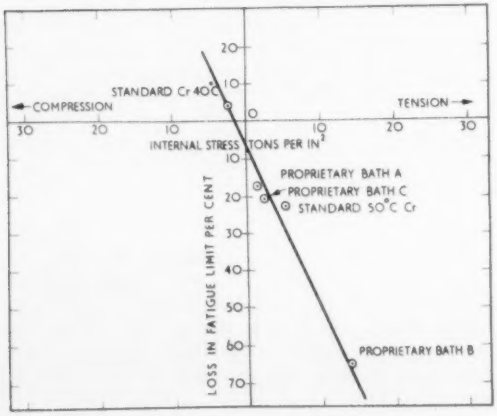
(Courtesy Institute of Metal Finishing).

The variation of tensile stress with depositing temperature is shown in Fig. 1, from which it is seen that under the normal depositing conditions (50°C. and approximately 200 amp. per sq. ft. C.D.). the internal stress is approximately 4 tons per sq. in. tensile.[2]

The internal stress is also dependent on the composition of the plating bath and a number of different proprietary chromium plating solutions have been tested giving deposits in which the internal stress ranged from approximately 1.5 to 14 tons per sq. in. tensile.

Fig. 2.—Linear relationship between percentage change in fatigue strength of chromium-plated steel and the internal stress of various types of chromium deposit for "as-plated" (i.e. unbaked) deposits.

(Courtesy Institute of Metal Finishing).



By plating rotating-bend fatigue test-pieces in these proprietary baths and in the standard bath at varying temperatures, it has been possible to establish a relationship, Fig. 2, between the internal stress of chromium deposits and the change in fatigue strength of a steel of 65 tons per sq. in. and this was found to be linear.[2]

Baked deposits

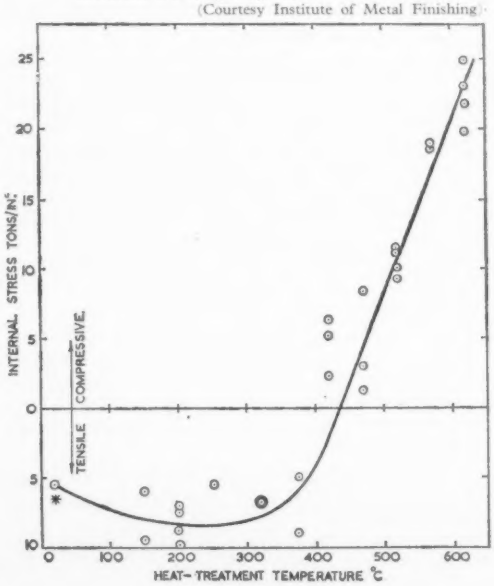
Chromium plated components are usually baked after plating to relieve hydrogen embrittlement of the steel and this process can profoundly affect both the internal stress in the deposit and the fatigue strength of the plated part.

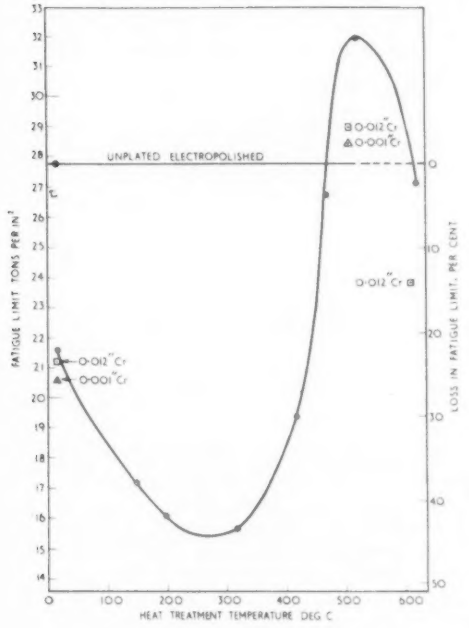
Fig. 3 shows the results of determinations of internal stress, after baking at various temperatures, followed by cooling, of chromium deposits 0.001 inch thick plated on one side of standard spring steel stress-strips.[2]

It will be seen that, as the baking temperature is increased, the initial tensile stress of approximately 5 tons per sq. in. increases slightly reaching a maximum at a temperature between 200 and 300°C. At higher temperatures, the tensile stress rapidly diminishes reaching zero at about 440°C. and ultimately becomes strongly compressive. The initial increase in tensile stress is, we believe, due to the permanent contraction which electrodeposited chromium undergoes on heating. At the higher baking temperatures complete stress relief

*Fig. 3.—Effect of heat treatment on the residual stress in chromium deposits 0.001 in. thick on steel strip. *Mean of 23 results 5½ ton per sq. in.; standard deviation 2.1 ton per sq. in.*

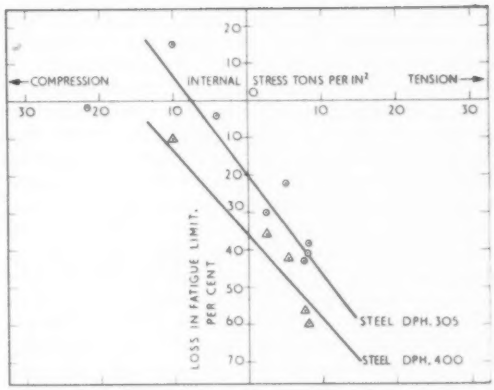
(Courtesy Institute of Metal Finishing).





occurs during baking and, on cooling, owing to the fact that the coefficient of thermal expansion of steel is almost double that of electrodeposited chromium, the deposit becomes compressively stressed.

The effect of these changes in internal stress upon the fatigue limit of steel was determined by chromium plating rotating-bend fatigue test-pieces and subjecting them to the same heat-treatments as were used for the stress strips (Fig. 4).



The striking similarity in the shape of this curve[2] to that of the stress curve (Fig. 3) confirms the important influence of internal stress on the fatigue strength of the plated component.

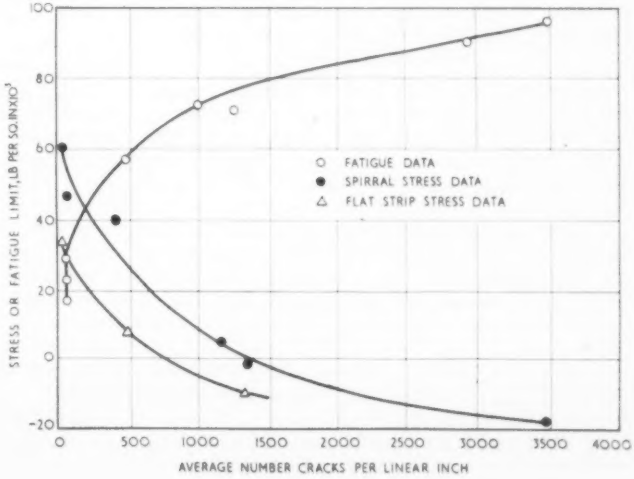
It has been shown that for "as-plated" (*i.e.* unbaked) chromium, the relationship between the internal stress in the deposit and the percentage change in fatigue strength of the plated steel is linear. By combining the data from the two previous slides it may be seen that for baked deposits also the relationship is a linear one.[2]

Fig. 5 shows the results for a steel tempered to strengths of 65 and 80 tons per sq. in. respectively. Within the limits of experimental error, the two lines are parallel and displaced from one another merely in accordance with the different fatigue limits of the unplated steels. Recent work of Stareck, Seyb and Tulumello[3] confirmed this linear relationship both for "as plated" and baked chromium plated steels and in addition,

Fig. 4.—(above left) Effect of heat-treatment on the fatigue limit of a steel of 60 ton per sq. in. T.S. plated with 0.006 in. chromium.
(Courtesy Institute of Metal Finishing).

Fig. 5.—(above right) Linear relationship between percentage change of fatigue strength of chromium plated steel and the residual internal stress in conventional chromium after baking.
(Courtesy Institute of Metal Finishing).

Fig. 6.—(right) Interdependence of fatigue limit of chromium plated steel with internal stress and crack density in the chromium deposit.
(Courtesy American Electroplaters' Society).


FATIGUE DATA
SPIRRAL STRESS DATA
FLAT STRIP STRESS DATA
STRESS OR FATIGUE LIMIT, LB PER SQ. IN. X10³
AVERAGE NUMBER CRACKS PER LINEAR INCH

threw interesting light on the relationship between the internal stress, the fatigue limit and the internal crack system commonly present in chromium deposits.

As long ago as 1947, Logan[4] at the National Bureau of Standards postulated that since the characteristic cracking of chromium indicated at least partial relief of residual stresses, specimens having the largest number of cracks per unit area would be expected to have the lowest residual stress and hence, by inference, the least effect in depressing the fatigue limit. This theory was strikingly confirmed by Stareck and his co-workers who, using a variety of chromium plating solutions both conventional and proprietary and confining their examination to unbaked deposits, counted the average number of crack lines that crossed an arbitrary line 1 inch long on the surface of the deposit. They also measured the internal stress of the deposits by two methods *viz.* the spiral contractometer and the bent-strip method. and their results are shown graphically in Fig. 6.

From this work they were able to deduce simple expressions relating the internal stress of the chromium and the crack density

$$S = K_I - 1.3\sqrt{C} \qquad (1)$$

and the change of fatigue strength of a steel of approximately 100 tons per sq. in. tensile strength.

$$F_p = F_s + 1.3\sqrt{C} - 85 \qquad (2)$$

where

- S = internal stress in lb. per sq. in. x 10^{-3}.
- K_I = a constant.
- C = number of crack lines per in.
- F_p = fatigue limit of plated steel in lb. per sq. in. x 10^{-3}
- F_s = fatigue limit of unplated steel in lb. per sq. in. x 10^{-3}

Relative Importance of Internal Stress as a Factor in Determining the Fatigue Limit of Plated Steel

Enough has been said to show that the internal stress of the deposit has an important influence on the fatigue strength of the plated steel. The relative importance of this factor depends very much, however, upon the strength of the steel substrate.

As a result of fatigue tests on a considerable number of steels of widely varying strengths it has been found that the percentage change of fatigue strength as a result of chromium plating is a linear function of the strength of the steel substrate.

This is shown in Fig. 7 in which the percentage change of fatigue strength is plotted against the fatigue limit of the steel.[5]

All these steels were plated with 0.006 inch of chromium from a conventional solution giving an internal tensile stress of approximately 4 tons per sq. in. It will be noted that the fatigue limit of the softest steel was actually *increased* by chromium plating whereas the strongest steels suffered a loss of fatigue strength approaching 50 per cent.

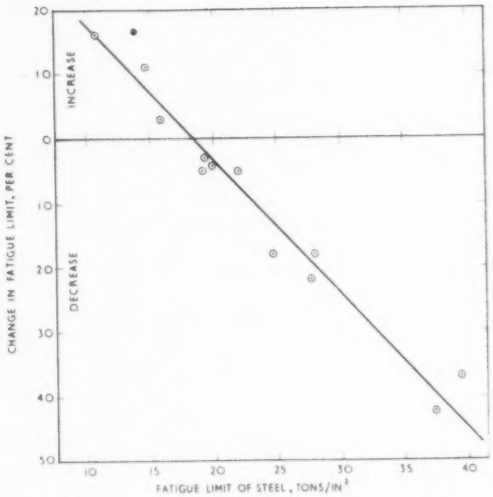


Fig. 7.—Linear relationship between the change of fatigue limit after chromium plating and the fatigue strength of the steel base. (Thickness of chromium 0.006 in. ; internal stress 4 ton per sq. in. tensile). (Courtesy Institute of Metal Finishing).

From the curve an equation may be derived

$$L = K - 2F_s \qquad (3)$$

where:

- L = per cent change in fatigue strength in tons per sq. in.
- K = a constant.
- F_s = fatigue limit of unplated steel in tons per sq. in.

from which the percentage change in fatigue limit may be calculated from a knowledge of the fatigue strength of the substrate. K is a constant depending on the internal stress of the chromium and the basic equation can be modified to take the stress factor into account as follows :—

$$L = -2Fs - 3S + 50 \qquad (4)$$

where L and F_s are as above and S= internal stress in tons per sq. in

With normal chromium deposits " as plated " in which the internal stress is numerically small compared with the sum of the other two factors, the influence of stress is slight and this is particularly true for the stronger steels with which are associated the greatest percentage losses in fatigue strength. Under such conditions the low inherent fatigue strength of the chromium (*ca.* 20 tons per sq. in.) relative to that of the steel, is probably the dominant factor.

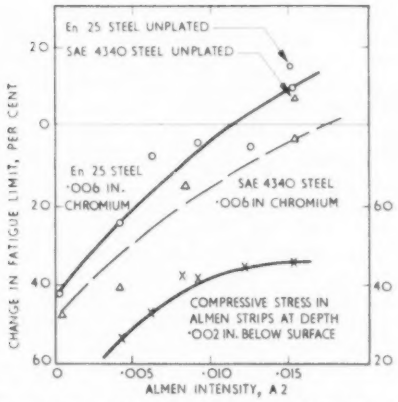


Fig. 8.—Effect of shot-peening before chromium plating on the fatigue limit of En 25 steel (80 ton per sq. in. T.S.) and SAE 4340 steel (100 ton per sq. in. T.S.) The lowest curve shows the calculated internal compressive stress 0.002 in. below the surface at various peening intensities.

(Courtesy American Electroplaters' Society).

On very weak steels the initial internal stress of the chromium will exert a more important influence but such steels are rarely used for machine parts.

In this discussion such variations in initial internal stress as may be found between different types of chromium plating solutions used under the normal conditions have been referred to. As has been shown, however, when a chromium plated component is baked at a high temperature, a high intensity of compressive stress is developed in the chromium on cooling and this does have an important influence on the fatigue strength on the class of medium strength steels for which this type of heat-treatment is appropriate.

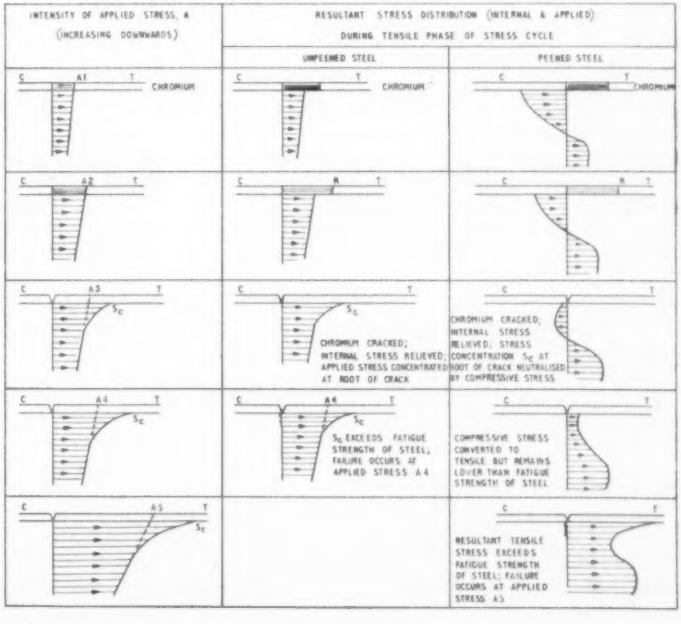

I = INTERNAL TENSILE STRESS IN CHROMIUM
A1, A2, ETC = NOMINAL APPLIED STRESS
R = TOTAL STRESS (INTERNAL & APPLIED) JUST SUFFICIENT TO CRACK CHROMIUM
Sc = RESULTANTS OF APPLIED STRESS & STRESS CONCENTRATED AT ROOT OF CRACK AT VARIOUS VALUES OF A
INTERNAL STRESS DISTRIBUTION AT POSITION OF MAXIMUM TENSILE STRESS P
UNPEENED (ELECTROPOLISHED) STEEL
PEENED STEEL
BEFORE PLATING
AFTER PLATING
COMPRESSION (C)
TENSION (T)
NO STRESS
INTERNAL STRESS IN CHROMIUM, I
STRESS DISTRIBUTION BEFORE APPLYING LOAD
INTENSITY OF APPLIED STRESS, A
(INCREASING DOWNWARDS)
RESULTANT STRESS DISTRIBUTION (INTERNAL & APPLIED)
DURING TENSILE PHASE OF STRESS CYCLE
CHROMIUM CRACKED; INTERNAL STRESS RELIEVED; APPLIED STRESS CONCENTRATED AT ROOT OF CRACK
CHROMIUM CRACKED; INTERNAL STRESS RELIEVED; STRESS CONCENTRATION Sc AT ROOT OF CRACK NEUTRALISED BY COMPRESSIVE STRESS
Sc EXCEEDS FATIGUE STRENGTH OF STEEL; FAILURE OCCURS AT APPLIED STRESS A4
COMPRESSIVE STRESS CONVERTED TO TENSILE BUT REMAINS LOWER THAN FATIGUE STRENGTH OF STEEL
RESULTANT TENSILE STRESS EXCEEDS FATIGUE STRENGTH OF STEEL; FAILURE OCCURS AT APPLIED STRESS A5

Fig. 9.—Suggested modes of fatigue failure of chromium plated steel.

(Courtesy American Electroplaters' Society).

Remedial Measures

For steels which can be baked after plating at 440° to 480°C., such treatment for say 1 hour will restore the fatigue limit to the 'as-plated' value or even, in some cases, to that of the substrate, and incidentally, will eliminate any hydrogen embrittlement in the steel. This treatment will reduce the hardness of the chromium, however, to approximately 600 HV, a value which will be sufficiently high for many purposes.

If it is desired to retain the full hardness of the chromium, or if the steel is such that it will not sustain heat-treatment at this temperature without loss of temper, then recourse may be had to shot-peening (or in suitable cases, rolling) the component before chromium plating. Shot-peening or rolling introduces compressive stress into the surface layers of the steel which, if sufficiently intense, will prevent propagation of a fatigue crack in the chromium into the steel. The in-

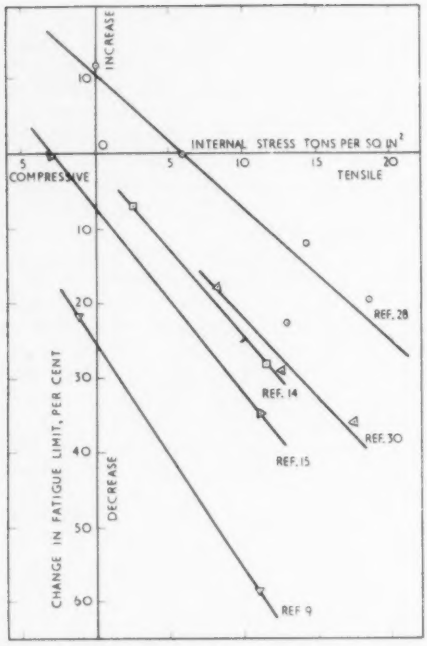


Fig. 10.—(above left) Linear relationship between the change in the fatigue limit of steel on nickel plating and the internal stress of the nickel deposit.

(Courtesy Institute of Metal Finishing).

tensity of shot-peening is controlled by varying the time of peening, the stand-off distance and the air pressure and is measured in thousandths of inch arc height of a standard steel strip (an Almen strip) when curvature is produced by peening one side only of the strip. In using this method to control the peening process the test-strip is peened under the same conditions as the components requiring treatment. Some of the results of shot-peening are shown in Fig. 8 from which it is clear that to be completely effective it is necessary that the peening intensity should reach a minimum value dependent to some extent on the strength of the steel being treated, *viz.*, approximately 0.012 A2 for a steel of 80 tons per sq. in. T.S. or 0.016 A2 for a steel of 100 tons per sq. in. T.S.[6] (*See* also Almen's results[10] (Fig. 15)).

The high tensile steels for which this peening treatment is required are particularly liable to hydrogen embrittlement during pickling and plating. It is necessary, therefore to bake them after plating to remove embrittlement and this can be done at 200° C. without detriment to the fatigue strength.

The immunity of shot-peened and chromium plated steel to loss of fatigue strength on low temperature baking follows from the mechanism attributed to the use of peening in this connection. Thus it is believed that on peened steel the chromium develops fatigue cracks at a comparatively low level of applied stress, *viz.* at the fatigue limit of the chromium (approximately 20 tons per sq. in.). The tensile stress concentrated at the root of the crack is neutralized by the compressive stress in the steel and the crack does not propagate until the resultant of the applied stress concentrated at the root of the crack and the compressive stress in the steel reaches a tensile value exceeding the fatigue limit of the steel. This is illustrated diagrammatically in the right-hand column of Fig. 9.[6]

Peening roughens the surface and, for running parts, it is necessary to restore the smoothness of the finish by grinding. This may be done either by grinding the peened steel before chromium plating (since the thickness of steel required to be removed for eliminating the peening texture is small in relation to the depth of the compressively stressed layer) or by grinding the chromium deposit after plating.

Nickel

In comparison with chromium there are little quantitative data on the effect upon the fatigue strength of internal stress in nickel deposits although there is a considerable amount of information on stress. The internal stress in nickel deposits from baths containing no addition agents is always tensile and may range from 5 to 20 tons per sq. in. or more. An exception is the nickel sulphamate solution which, in the absence of chloride, may have a tensile stress as low as 500 lb. per sq. in. It is

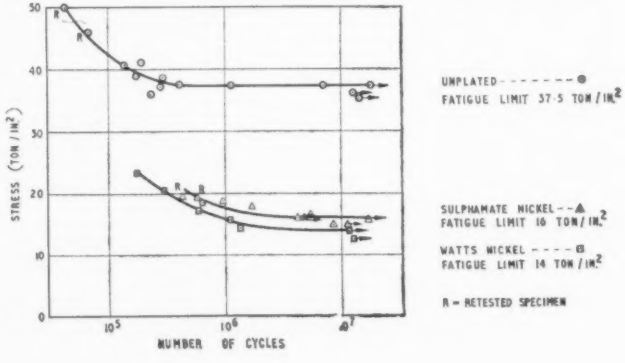


Fig. 11.—(right) S-N Curves of En 25 steel of 80 ton per sq. in T.S. electropolished and plated with 0·006 in. nickel.

(Courtesy Institute of Metal Finishing).

Table I

Results of hardness, tensile and bend tests on nickel deposits. (Fanner and Hammond[7])

Material and Test No.		Hardness (V.D.H.) Front		Hardness (V.D.H.) Back*		Tensile Tests T.S. (ton/in²)		Tensile Tests Elongation (% on 2-in gauge length)		Tensile Tests Reduction of Area %		Jenkins Bend Tests No. of 180° bends using 1mm radius jaws
Sulphamate Nickel												
Test No.	1	162		175		28.7		18.5		36.9		
	2	161		179		30.8		18.5		34.3		
	3	160		180		29.4		19.5		39.4		(Mean of
	4	154	160	181	179	30.0	29.8	19.5	19.5	41.7	39.5	25 20 tests)
	5	158		178		30.5		21.5		40.2		
	6	162		180		29.6		19.5		44.5		
Watts Nickel												
Test No.	1	139		183		28.8		†		†		
	2	147		181		30.4		23.0		34.3		
	3	145		182		29.6		23.5		39.1		31 (Mean of
	4	141	141	172	178	28.4	29.0	23.0	23.0	41.9	39.7	20 tests)
	5	139		172		28.0		22.0		43.3		
	6	134		177		28.7		9.5‡		23.5‡		

* Starting surface.
† Fractured outside 2-in. gauge length.
‡ Fractured at a pit in the test-piece.

known that tensile stress in the nickel is one of the factors which contributes to the lowering of the fatigue strength when steel is nickel plated and there is fairly conclusive evidence that, as in the case of chromium, there is a linear relationship between the internal stress in the nickel deposit and the change in the fatigue strength.

This is shown in Fig. 10 which includes data from five sources in the literature.[5]

A low value of internal stress promotes minimum loss of fatigue strength and vice versa. It follows therefore that, for engineering applications in which there is a fatigue hazard, low stress nickel baths, or preferably baths giving a compressive stress should be used.

In this connection, the nickel sulphamate bath has attracted considerable attention in recent years. As already stated, this bath used "straight," *i.e.*, without stress-reducing addition agents, gives a deposit of very low tensile stress. The addition of some chloride, which in our view is necessary to ensure anode corrosion, increases the tensile stress. However, the addition of 3.3 gm. per l. nickel chloride, which in our experience is sufficient to ensure anode corrosion, only raises it to about $1\frac{1}{2}$ tons per sq. in.

Fatigue tests were carried out with a bath of this type and the results are shown in Fig. 11.[7]

Parallel tests were carried out with a Watts bath giving a deposit of 5 tons per sq. in. tensile stress. Comparison of the S-N curves shows that both deposits lowered the fatigue strength of the 80 tons per sq. in. steel by approximately 60 per cent and the improvement obtained with the low-stress sulphamate bath was only marginal.

It can be seen from Table I that the mechanical properties of the sulphamate and Watts nickel deposits were almost identical (T.S. 29.8 and 29 tons per sq. in. and elongation 19.5 and 23 per cent respectively) and it seems clear that, in this case, the dominant factor was the low inherent fatigue strengths of the nickel deposits (approximately 15 tons per sq. in.) compared with that of the steel (approximately 38 tons per sq. in.). Thus both types of nickel cracked in fatigue at a relatively low applied stress and subsequent failure of the steel was determined by the stress concentration at the root of the crack.

It is evident that the use of a low-stress nickel deposit is not in itself sufficient to prevent a serious loss of fatigue strength in a medium-or high-strength steel.

There are two methods of reducing or, on weak steels, eliminating the loss of fatigue strength on nickel plating *viz.* the use of stress-reducing addition agents in the plating solution or shot-peening.

Addition Agents

Certain addition agents, for example naphthalene trisulphonic acid, paratoluene sulphonamide or saccharin when present in small concentrations reduce the tensile stress in the nickel deposit. Higher concentrations reverse the direction of the stress causing it to become strongly compressive.

These effects may be illustrated by two graphs, Figs. 12 and 13, taken from a paper by Diggin[8] showing the effect on the internal stress of adding various concentrations of naphthalene 1,3,6,-trisulphonic acid (NTS) to a nickel sulphamate solution.

These graphs show that compressive stress of approaching 10,000 lb. per sq. in. may be obtained by additions of from 8 to 12 gm. per l. of NTS to a solution containing 30 gm. per l. of nickel chloride which, in the absence of the addition agent

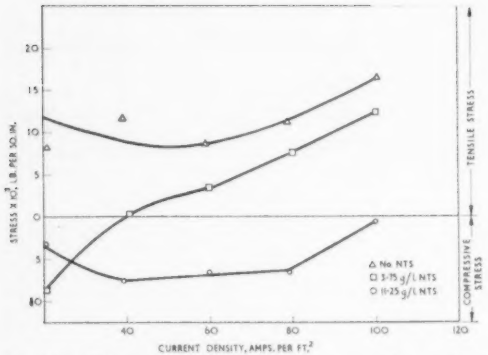


Fig. 12.—Effect of addition agent concentration and of current density on the internal stress of nickel deposits from a sulphamate bath at 38°C (100°F). (Diggin).

(Courtesy Institute of Metal Finishing).

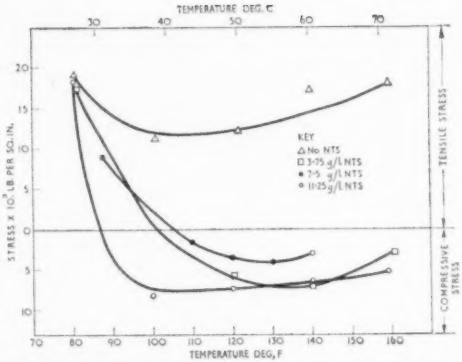


Fig. 13.—Effect of addition agent concentration and of temperature on the internal stress of nickel deposits from a sulphamate bath at current density 40 amps per sq. ft. (Diggin).

(Courtesy Institute of Metal Finishing).

gave a fairly high tensile stress of from 8000 to 17000 lb. per sq. in., according to the current density and temperature. They also show that, for any given concentration of addition agent, the stress is dependent upon the current density and the temperature in the plating process. Barrett[9] shows similar results but he does not specify the precise nature and concentration of the addition agent used.

Almen was probably the first to suggest the use of addition agents to nickel solutions for the purpose of improving the fatigue properties. He describes some fatigue tests in which a weak steel of 45,000 lb. per sq. in. fatigue limit (40 tons per sq. in. T.S.) suffered a reduction in fatigue strength of 35.5 per cent when plated with a nickel deposit of 25,000 lb. per sq. in. tensile stress and a slight gain in fatigue strength when plated with a compressively stressed nickel of 6000 lb. per sq. in.[10] A graph of the effect on fatigue strength is shown in Fig. 14.

In a recent paper Scott[11] shows that nickel plating a hardenable stainless steel of 65-80 ton per sq. in. T.S. in a sulphamate solution controlled to give a compressive stress of 7,500 lb. per sq. in. resulted in a loss of fatigue strength of only 1.3 per cent. On the other hand Stareck[3] found that plating a steel of 100 tons per sq. in. T.S. in a bright nickel bath with a compressive stress of 3000 lb. per sq. in. merely reduced the fatigue limit loss from 59 to 22 per cent.

It would seem therefore that the effectiveness of compressively stressed nickel deposits depends upon the strength of the steel substrate ; on weak or medium strength steels the loss of fatigue strength may be eliminated or the fatigue limit after plating may even be slightly increased whereas on high strength steels the effect will be merely to reduce the loss of fatigue strength. The effect of the inherent fatigue strength of the nickel relative to that of the steel substrate becomes increasingly important with increase in strength of the steel.

In this connection it is necessary to point out that the use of these addition agents in nickel baths increases the hardness and tensile strength and also the inherent fatigue strength of the nickel and this, quite apart from the compressive stress, will contribute materially to the improvement in fatigue properties.

(*Continued in page* 449)

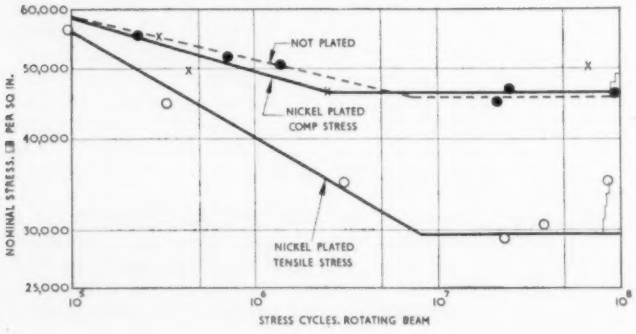

NOMINAL STRESS, LB PER SQ IN.
NOT PLATED
NICKEL PLATED COMP STRESS
NICKEL PLATED TENSILE STRESS
STRESS CYCLES, ROTATING BEAM

Fig. 14.—Fatigue strength of steel plated with controlled compressive stress in nickel deposit (Almen).

(Courtesy " Product Engineering ").

Stresses in Hard Chromium and Heavy Nickel Deposits and their Influence on the Fatigue Strength of the Basis Metal.

(*Continued from page* 448)

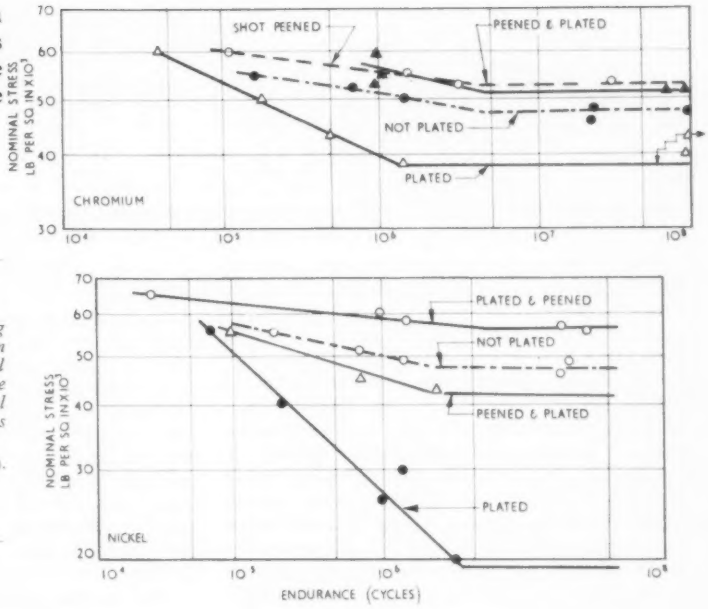


Fig. 15.—Effect of shot-peening before or after chromium (above, right) and nickel (right) plating on the fatigue strength of steel rotating beam specimens (Almen).

(Courtesy "Product Engineering").

Shot-peening

As in the case of chromium plating, shot-peening is an effective way of preventing loss of fatigue strength on nickel plating.

Electrodeposited nickel from "straight" baths is ductile and readily work-hardens and acquires compressive stress on peening. In this case therefore it is possible to shot-peen the deposit after plating as an alternative to peening the component before plating.

Almen gives the results of fatigue tests of nickel plated steel of approximately 50 ton per sq. in. T.S. peened by both methods compared with the same steel plated in the unpeened condition (fatigue limit loss approximately 60 per cent),[10], Fig. 15.

In the specimens peened before plating the fatigue limit of the steel was almost (but not quite) restored to the unplated value. In those peened after plating, the fatigue limit substantially exceeded the unplated value, but this difference may not be significant.

Summary

To sum up, chromium or nickel plated coatings which have a lower inherent fatigue strength than the steels to which they are normally applied, promote fatigue failure of the steel by themselves cracking thus concentrating stress at the root of the notch so formed, leading to propagation of the crack through the steel.

Tensile stress in the deposit will encourage cracking at a lower applied stress and a linear relationship between the internal stress in the deposit and the percentage loss in fatigue strength of the steel has been established for both chromium and nickel deposits.

Internal tensile stress in the deposit is only one factor in promoting fatigue failure and becomes relatively less important than the other factor (the inherent fatigue strength of the coating) as the strength of the basis-metal increases.

Loss of fatigue strength on chromium plating may be diminished or eliminated either by baking the component at 440° to 480°C. after plating or by shot-peening before plating. In the case of nickel plating these results may be achieved either by using an addition agent in the bath to convert the normal tensile to compressive stress (and incidentally to harden and strengthen the deposit) or by shot-peening before or after plating.

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A Quarterly Survey of some of the Features in Finishing Literature from Abroad

by **SCRUTATOR**

MUCH has been written, is still being written and has yet to be written about the intrusions which aluminium can make into the traditional markets for steel, particularly those of motor-car bumpers and the packaging of food and beverages etc. A staff report prepared by one of the American finishing journals under the title "How About Aluminium Auto Bumpers"[1] is, therefore, of considerable interest to aluminium finishers in this country. It is suggested that the interest in aluminium is because the American steel bumper market is now so competitive that suppliers just dare not ignore any move which would put their competitors one move ahead of them. Further of course, the possibility of a coloured finish, weight savings and the absence of red rust all stimulate interest in aluminium. On the other hand however, adverse factors include price, the suggestion that anodized finishes are not tough enough to withstand the impact of flying stones etc. and a growing tendency for the use of caustic washes in the American 60-second car wash plants which would adversely affect anodic films. In fact, one large manufacturer has been quoted as saying that aluminium bumpers must be plated before they become standard equipment on a car. Accordingly, there is probably more work on plating aluminium than anodizing being carried out in America but adhesion is a problem. Additionally, the strength and formability of aluminium present their own problems, and the report concludes that in practical terms "the steel bumper still seems to be pretty well entrenched."

The "tin can" is the traditional container for a wide variety of foods, beverages and many industrial chemicals. After a 2-year development programme the Kaiser Aluminium and Chemical Corporation have now installed a fully automatic plant at their Trentwood, Washington factory for processing aluminium sheet and coil to meet the requirements of the can-manufacturing industry[2]. They anticipate that the 40 million lb. of aluminium used in this field in 1960 will have risen to 100 million by the end of 1961, and the equipment includes a strip processing line involving a 5-stage pretreatment followed by an organic coating on one or both sides of the coil. The coated coil is then despatched to the manufacturer for fabrication into containers.

Galvanizing and Cars

Widman[3] has published a most interesting account of the work carried out by the Ford Motor Company in America on the use of galvanized steel to improve corrosion resistance. It is stated that the need for improved corrosion resistance has risen because, due to unitised design, "structural integrity" is required ; the lighter coloured finishes now so popular, in addition to drawing attention to rust streaks have less protective qualities than the darker finishes previously employed ; and the increased use of de-icing chemicals on American roads has accentuated the corrosion problem.

The following points seem of particular interest to all those connected with metal finishing.

For reasons of economy, hot-dip galvanized steel is preferred to electrogalvanized and it was originally found that paint applied by conventional methods did not adhere too well and resistance to blistering was not good. Adhesion could be improved by cleaning the galvanized steel with steel wool, or wire brushing, followed by phosphating, and the blistering could be overcome by a skin-pass as the blistering followed the line of wiping of the hot-dip galvanized surface. By introducing a new cleaner and phosphating solution in their pretreatment sections however, they have now dispensed with the need for wire brushing and claim a much better phosphate coating than previously, on both the galvanized and plain steel body areas. Further, improved welding techniques have enabled them to use the readily commercially available hot-dip-galvanized material with the same coating of zinc on each side of the sheet.

The present Lincoln Continental and Thunderbird cars contain over 200 lb. of hot-dip-galvanized material per car, which, after phosphating, is dip-painted to a depth of 18 in. in a water emulsion primer.

In contrast, in order to ensure maximum protection of the Rambler automobile manufactured by American Motors Corporation, the body is phosphated in a standard 6-stage plant and then completely immersed in a 12,000 gallon tank of an epoxy resin primer[4].

(*Continued in page* 461)

A Report of the CONFERENCE on ANODIZING

ORGANIZED BY

THE ALUMINIUM DEVELOPMENT ASSOCIATION AT THE UNIVERSITY OF NOTTINGHAM

(Specially contributed to "Metal Finishing Journal")

FROM Sept. 12 to 14. the University of Nottingham acted as host to the Conference on Anodizing organized by the Aluminium Development Association. Here was assembled an array of talent and experience, in both the practical and theoretical aspects of anodizing, such as has not hitherto been seen. The attendance of over 270 people reflected the widespread interest aroused by the programme and the presence of a significant number of foreign visitors from countries such as Sweden, Holland, Belgium, France, Germany, Italy, Czechoslovakia, Hungary, Canada, New Zealand and the United States, indicated its international stature.

Papers, totalling 18 in all, had previously been circulated to those who had registered, and although the interval between their receipt and the opening of the Conference was sufficient to enable several of them to be read before the Conference, few would have even contemplated attempting to scan all of them. Indeed, so comprehensively did the papers cover the field, that there was hardly an aspect of anodizing which was not touched on in at least one paper. While the contributions were overwhelmingly from British authors, there were two offerings from the United States, one paper from Germany and one from France.

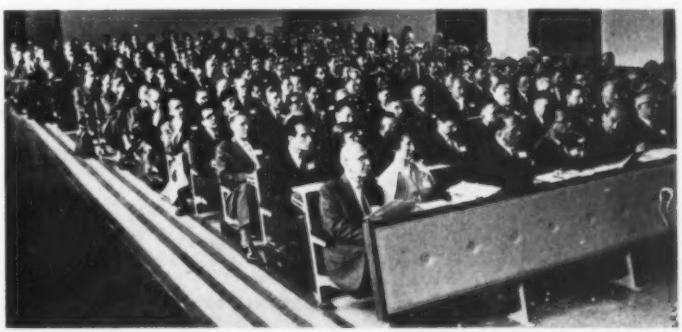
The choice of Nottingham University as a venue was a happy one, since it afforded an opportunity for numerous informal contacts outside of the period devoted to formal sessions. It was also a convenient location in terms of enabling people to avoid absence from their offices or laboratories for more than two days. The only criticism that could be levelled at the social arrangements was the lack of facilities, other than a film show, for those who chose to remain on the second evening. The Conference arrangements were satisfactory, with a full opening session on the Tuesday afternoon and the first part of Wednesday morning, followed by the device of simultaneous sessions for the remaining papers, thereby separating those with more theoretical interests from those preferring the practical papers. There were certainly a number of people who regretted that the division was necessary, for none other than the obvious reason that good practice stems from sound theory.

The papers presented were the following :—

Session 1

"*Current Trends in Materials for Anodizing.*"
J. W. CUTHBERTSON and J. C. BAILEY.

"*Control of Quality of Anodic Finishes.*"
J. G. SIMMONS.



Delegates at the first session of the A.D.A. Conference on anodizing.

"*The Properties and Performance of Anodic Finishes*"
J. M. PERFECT.

Session 2

"*Bright Anodized Aluminium Surfaces*"
B. A. SCOTT and H. M. BIGFORD.
"*Colour and Texture in Anodic Finishes—Reflectivity Considerations*"
E. F. BARKMAN.

Session 3

"*A Theory for the Formation of Anodic Oxide Coatings on Aluminium*"
J. F. MURPHY and C. E. MICHAELSON.
"*Characteristics of Barrier-Type Coatings for Electrolytic Capacitors*"
R. W. FRANKLIN.
"*Study of the Growth Process of Primary Films on the Surface of Aluminium*"
H. GINSBERG and W. KADEN.

Session 4

"*Anodic Finishes for Decorative Applications*"
T. E. V. STEPHENSON.
"*Anodic Finishes for Electrical Insulation*"
J. J. LEE.
"*Anodic Finishes for Wear Resistance*"
W. J. CAMPBELL.

Session 5

"*Theoretical Aspects of Electrolytic and Chemical Polishing*"
A. W. BRACE and J. M. KAPE.
"*Mechanism of Dyeing Anodic Coatings*"
C. H. GILES.
"*Influence of Sealing Water Impurities on the Quality of the Oxide Film*"
H. RICHAUD.
"*The Sealing of Porous Anodic Oxide Films on Aluminium*"
T. P. HOAR and G. C. WOOD.

Session 6

"*Some Pre-Anodizing Techniques for Decorative Work*"
V. F. HENLEY.
"*Multi-colour Dyeing of Anodized Aluminium*"
P. MILLETT.
"*Techniques for Architectural Anodizing*"
CAPT. J. FOX-WILLIAMS and H. L. WATTS.

First Technical Session

The opening paper by CUTHBERTSON and BAILEY is of particular interest to anodizers, who have long known that variations in composition and structure of the material supplied can affect the finished produced. Indeed, it is now well-recognized that both anodizer and metal supplier must co-operate closely where a high degree of uniformity of finish is required. The process used by the anodizer can affect the manufacturing technique required from the metal producer. This paper provides a useful summary of some of the problems involved in producing materials for anodizing and the progress made in producing special materials for anodizing. The most ambitious section of the paper is that in which the authors attempt to allocate the responsibility for various aspects of producing finished articles between metal supplier, fabricator, anodizer and ultimate customer. Here is material that can be studied with benefit to all concerned. Finally the paper deals with the vexed problem of the nomenclature of finishes and offers for consideration the system of designation devised by the Aluminium Company of Canada.

The following paper by SIMMONS on quality control may well explain the great advances made in the application of anodized finishes in many industries. Gone are the days when the strip-and-weigh method was the only means of measuring film thickness and the anthraquinone violet dye test the sole means for checking sealing. It is now possible, thanks to advances in electronics, to measure non-destructively, with a fairly high degree of accuracy, the thickness of coating on a component. Exposure in a moist atmosphere containing sulphur dioxide has been found to provide a useful indication of quality of sealing, for in this test badly-sealed work produces a pronounced white bloom. Corrosion resistance is frequently assessed by exposure to acetic acid salt spray, sometimes with the addition of copper salts, or by measuring current flow when the anodized article is placed in solutions of this type and connected to an external potential. The author warns that all the accelerated tests have their limitations and may not always show up the operative defect in quality even if for no other reason than that the rate of attack has to be speeded up in some way if the test is to be used for routine control. Methods of assessing visual and reflective properties, colour, electrical properties, wear and abrasion resistance are also described.

In many respects the accompanying paper by PERFECT is complementary to that of SIMMONS. In it is discussed the nature and structure of anodic coating and the suitability of alloys for various kinds of anodic finishes is tabulated. The rest of the paper is a catalogue of most of the physical properties of the film likely to be of practical interest including visual and infra-red reflectivity, heat resistance, emissivity, electrical resistance and breakdown voltage, weather resistance specific gravity, refractive index and hardness.

Some data is included on the effect of material and anodizing conditions on some of these properties.

Second Technical Session

The papers by SCOTT and BIGFORD, and by BARKMANN, on various aspects of assessing the surface reflectivity and appearance of anodized aluminium will be read with interest by all those who have attempted to find a satisfactory instrumental method for inspecting bright anodized aluminium instead of the traditional subjective visual inspection. The discussion revealed that the human eye is indeed unique in its ability to integrate the overall impression of a surface, instead of the limited area measured at any one time by an instrument, but rarely do two eyes see the same thing or remain unbiased in their judgement. An instrument is not liable to subjective bias, and given that the materials and finishing techniques are under reasonable control these papers show that instrumental techniques are available which enable surface quality to be measured.

The contribution to the discussion by Mr. G. L. MILLER (Ford Motor Co.) revealed that anodized aluminium can now be regarded as an accepted finish in the motor-car industry for trim applications. His plea that an anodized finish should be accepted in its own right, without simply attempting to imitate other trim finishes, will find a sympathetic response in many quarters. Indeed there is much to be gained from this approach since anodized aluminium has greater versatility than other trim materials in respect of the combinations of colour and texture obtainable.

The papers so far presented revealed the considerable technology which has been built up in the post-war years. There is no doubt that many industrial operations can be carried out economically, simply by accumulated experience, which enables, often by trial and error, the best method to be laid down as to how they should be performed. This is satisfactory provided all problems can be solved within this framework. Often it is necessary to know why such processes are satisfactory, and this eventually resolves itself to a more fundamental examination and with it a resort to theory of basic reactions. It was encouraging to find not only that this practical advance had been accompanied by a wide range of theoretical studies of the mechanism of processes associated with anodizing, but that the theoretical workers were conscious of practice and were themselves engaging in healthy controversy over their models.

Third Technical Session

Indeed the theoretical sessions provided some of the liveliest discussion of the whole Conference. Probably the most controversial paper was that by MURPHY and MICHAELSON "A Theory for the Formation of Anodic Oxide Coatings on Aluminium." For many years the somewhat over-simplified model of an oxide cell consisting of barrier layer, cell walls and central pore has been accepted, its dimensions measured, and correlations established with anodizing conditions, particularly the electrolyte and anodizing voltage used. The oxide solvent effect of the electrolyte has been invoked to explain pore formation resulting from its attack on the oxide and the establishment of equal fields associated with each pore to account for the even distribution of pores.

MURPHY and MICHAELSON have obviously been impressed by STIRLAND and BICKNELL'S observations that even the non-porous barrier-type coatings have been found to possess a non-uniform structure ; indeed they might be regarded as having incipient pores. Further, they have observed that previous explanations have not accounted for the presence in the anodic coating of ions from the electrolyte, sometimes in appreciable amounts. They suggest that the anodic film is not uniform in its structure, that nearest the metal being a relatively compact and anhydrous oxide, probably non-uniform with sub-microcrystallites of ordered structure, but with increasing distance from the metal surface a hydrated outer layer dominates. They believe that conduction occurs through the hydrated outer porous layer and results in the reaction of aluminium ions and oxygen carriers in the interphase with the subsequent conversion of the barrier layer to porous layer and the movement of the barrier layer into the metal.

The incorporation of sulphate into the anodic coating is explained as part of a proton transfer process which is facilitated by the ease of movement of the hydrogen bonded proton from one sulphate molecule to the next. It was pointed out in the discussion that the ease with which a sulphate ion will fit into the oxide lattice is another probable factor. Pore formation is considered to be associated with a rearrangement and crystallisation of the aluminium hydroxide gel formed by the hydrated outer layer under the influence of heat produced by the flow of electric current through the resistive anhydrous oxide.

This proposed mechanism was welcomed as an attempt to explain several facts inadequately accounted for by previous theories but was criticised on a number of grounds including the difficulty of explaining what happened to the film on sealing. The authors admitted that they still had more to do to perfect their model, and it is to be hoped that other workers will also be stimulated to fresh thinking in this vital but most complex field.

The papers of FRANKLIN and GINSBERG and KADEN, provided a useful background against

which to appreciate the previous paper. FRANKLIN drew on the work of his colleagues STIRLAND and BICKNELL, supplemented by his own extensive research, to show that the barrier type coatings produced an electrolytic capacitors were not quite the simple, uniform, non-porous coatings that had hitherto been assumed. Indeed they seem to have much closer affinities to the so-called "porous" type coatings than had previously been recognized. GINSBERG and KADEN reported a series of electrical measurements on anodic coatings of various thickness and formed on metal given various pre-treatments. The efficiency of barrier layer formation was found to be influenced by pre-treatment, but when formed over a porous film to increase with the thickness of that film. The purity of the aluminium was also found to affect the efficiency of the forming process, tending to decrease with decrease of metal purity.

Fifth Technical Session

The second theoretical session also provided stimulating material. The two papers on sealing, one by RICHAUD of Pechiney and the other by HOAR and WOOD aroused the main discussion. The latter paper described a theoretical study of the sealing process using electrical measurements, whilst that of Richaud reported a careful evaluation of the effects on sealing of additions to distilled water and de-ionised water having a resistivity of not greater than 1 x 10^6 ohm cm. The techniques used for evaluation included measurement of a.c. conductance of the film, an ink penetration test, and resistance to dissolution in nitric acid (pH = 1) over 200 hours at 20°C.

These tests showed that there are several ions which can be present in the sealing water which clearly reduce the chemical resistance of the film. These include 5 mg. per l. PO_4 and 10 mg. per l SiO_3, Cu and Fe and fluorides in slightly higher amounts. Some constituents such as aluminium, sodium, sulphates and (surprisingly) hypochlorites have practically no effect on the quality of sealing. Indeed it was found that provided the pH is correctly controlled the small amount of alumina which inevitably dissolves in the sealing water has no harmful effect, and that the pH of the sealing bath can be satisfactorily controlled by additions of dilute caustic soda or sulphuric acid solutions without undesirable side effects. It was also found that small amounts of Calcium, or preferably magnesium at 100-150 mg. per l, improved the chemical resistance of the anodic coating.

The contribution from GILES is of two-fold interest. First, the investigations providing the background material for the paper came from an academic study of the mechanism of absorption. Alumina is well known for its absorptive characteristics which find various industrial applications. The study of dyeing of anodic coatings arose incidentally from this broader study in which it was hoped to show what factors decided whether there was merely physical absorption, or a more complex physico-chemical bond formation. Second, it is one of the very few papers that has considered the fundamentals of a practical process which has been in everyday use for over twenty years.

GILES concludes that with sulphonated acid wool dyes they either form a co-valent bond between their sulphonate groups and aluminium atoms on the surface, or enter into an ion exchange reaction, remaining as charged anions singly or as miscelles at the surface. Mordant dyes form chelate complexes with the alumina. The stages in dyeing appear to be (i) etching of the surface layer with consequent increase in surface area, (ii) rapid absorption of an external layer of dyestuff, and then (iii) slow inward diffusion of dye along the minute pores in the film. Adequate sealing which prevents access of air and moisture, is believed to play an important part in securing high light-fastness.

The paper by BRACE and KAPE drew attention to the essential unity of the mechanisms of chemical and electrolytic polishing, in that they both depended on the suppression of preferential removal of metal which would give rise to etching. Chemical polishing occurs without the application of an external current, the necessary current being provided by the chemical system. The authors distinguish between macro- and micro-polishing and suggest that different mechanisms apply to these phenomena. They also report some useful experimental results on the effect of nitric acid content in phosphoric acid based chemical brightening baths.

Fourth Technical Session

The papers dealing with the applied aspects fall into two groups, those concerned with the applications of anodized aluminium, and those describing advances in anodizing techniques. Of the former group the contribution by STEPHENSON represents an attempt to review within a small compass the multitudinous range of applications of anodic finishes. Written from the standpoint of a material producer it was perhaps inevitable that architectural and other external applications should receive first mention, since they presumably account for a greater actual or potential tonnage of aluminium than do the larger group (numerically at least) of decorative and general engineering uses. However, the author succeeds in providing a useful selection of applications, in many fields, sufficient to stimulate the thoughts of any potential customer.

(*Continued in page* 464)

6TH INTERNATIONAL CONFERENCE ON HOT-DIP GALVANIZING

INTERLAKEN JUNE 5-9, 1961

(*Continued from page* 413, *November Issue*)

Session 6a

Chairman : MR. C. ORIGONI
(Origoni and C. Metalli)

The Influence on Alloy Additions on Hot Galvanizing

J. J. SEBISTY and R. H. PALMER
(Mines Branch, Dept. Mines and Technical Surveys, Canada. Canadian Zinc Research and Development Comm.)

THE authors have investigated the structure and properties of laboratory-prepared galvanized coatings on steel sheet, as affected by combined additions of aluminium, tin, cadmium, antimony and copper to iron-saturated zinc baths, and they found the most important single factor affecting the thickness, structure, forming properties, surface appearance and storage-stain susceptibility of the experimental coatings was the aluminium content of the bath. Bath temperature and immersion time modified the behaviour of aluminium. Statistically the influence of tin, cadmium, antimony and copper was minor to negligible, except with respect to surface appearance and storage-stain corrosion of the coatings.

It appears from the investigation that with 0.15 per cent or higher aluminium in the bath up to 0.60 per cent each of tin, cadmium and copper and 0.04 per cent antimony, separately and in combination have relatively little effect on coating properties so long as the immersion time is short and the bath temperature is at or near the optimum of 842 F.

If these time-temperature conditions are exceeded, partial neutralization of the inhibiting effect of aluminium, and the development of non-uniform coatings with relatively poor ductility and adherence can be expected, particularly in the presence of copper and cadmium.

For lower aluminium concentrations which are not sufficient to prevent appreciable iron-zinc alloy formation the authors conclude that :

(a) No improvement in the basically poor forming properties of such coatings can be expected even with excessive additions of tin, cadmium, antimony and copper to the bath. Where these are present in significant amount an aluminium addition of the order of 0.05 per cent appears to serve no useful purpose other than as a brightener.

(b) The only practical advantage to be expected from deliberately alloying the bath with tin, cadmium and antimony is an improvement in surface appearance, particularly with respect to production of a lustrous spangled finish. The tests demonstrated that spangle size and contrast as well as coating brightness, can be varied widely by individual or combined additions of these elements, depending on the time-temperature conditions used, and the amount of aluminium and lead in the bath.

(c) Tin or cadmium in high concentrations in excess of 1.0 per cent appear to be ineffective in promoting appreciable spangle growth with lead-free baths. A superior response can be obtained with significantly smaller amounts when 0.5 per cent Pb is also present.

(d) A high lead content is beneficial in promoting brighter coatings but an accompanying disadvantage is a reduction in surface smoothness due to depression of spangle boundaries. The latter could be overcome by lowering the lead level, but, in production operation this would limit other benefits relating to dross formation and removal which are generally associated with excess lead in the bath. Addition of tin and/or cadmium in amounts of the order of 0.06 per cent appears to offer an alternative solution.

(e) Copper promotes more rapid zinc attack on the steel surface and is also detrimental to coating surface appearance. Since it offers no practical advantages to offset these harmful effects the use of zinc with a high copper content or adding copper for alloying purposes should be avoided.

The Influence of Bath Temperature, Immersion Time and Aluminium Concentration on the Structure and Properties of Galvanized Coatings

R. SOUSKE
(Zinc et Alliages, Levallois-Perret, France)

SOME useful practical conclusions have been drawn from the rather unusual results obtained by the author from his experiments. One is the possibility of producing a heavier coating by the addition of aluminium in certain small concentrations to the bath. This could prove beneficial to those industries which have abandoned the use of aluminium additions because of the lowering in coating weight which normally occurs.

Also tests by the cupping test have indicated that the coating ductility is chiefly influenced by the delta alloy layer and relatively small changes in bath temperature, and immersion time can have a marked effect on coating adhesion.

Finally it is shown that it is possible to produce, by conventional sheet galvanizing methods, coatings which have the properties similar to those of continuously galvanized strip.

The basis of the author's next investigation will be to determine the influence of the common impurities found in galvanizing baths on the structure and properties of the coating.

The Effects of Agitation, Cooling and Aluminium on the Alloying Behaviour in Hot Dipping in Zinc

D. I. CAMERON and M. K. ORMAY
(Central Research Laboratories, Newcastle, N.S.W. of John Lysaght (Australia) Pty. Ltd.).

THE amount of agitation, the speed of cooling and the degree of saturation can be important variables when considering the use of aluminium in galvanizing baths. From their results, the authors conclude that the importance of these variables depends on the aluminium level, being most important in the range 0.08 to 0.25 per cent Al, which is of greatest commercial interest.

In a fresh bath below dross saturation, dissolution of the steel base or alloys can occur, but this can also happen for high iron activity phases in a dross-saturated bath, particularly if the aluminium inhibits alloy layer formation by suppression of the rapidly forming binary iron-zinc alloys.

During the induction period in the presence of aluminium, parts of the surface are dissolving with no alloy formation, but at isolated spots, alloy layers are nucleated and grow till they cover the surface. With aluminium below about 0.15 per cent, local areas of aluminium depletion at a static surface can trigger off Fe/Zn binary alloy growth, associated with a lower aluminium content which will be self-perpetuating once it starts. Continuous agitation will lead to the ultimate deposition, at certain points, of a layer of the appropriate dross phase, which will grow, but which may with time transform to the nearest zinc-rich phase.

In a binary system, the structures represent an isothermal cross-section of the binary equilibrium diagram. In a ternary system this single cross-section is replaced by a number of alternatives which can be expressed in terms of a schematic ternary activity diagram. With high agitation, cross-sections towards the high-aluminium side will be favoured. With medium and high aluminium contents, the structures will begin by favouring the high aluminium type of behaviour and later switch to the zinc-rich type of structure by transformation and subsequent growth.

A number of effects thought to be due to dipping conditions, have been shown to occur during cooling, and the consequences of agitation and bath saturation are also of more practical importance than has hitherto been realized.

The range 0.1 to 0.2 per cent Al is particularly susceptible to all these variable effects and what has been found at a temperature of 450°C should apply with appropriate minor changes to other temperatures.

The Effect of Alloy Additions on the Properties of Hot Galvanized Coatings

W. RADEKER, F. K. PETERS and W. FRIEHE
(Phoenix-Rheinrohr A.G., Mulheim/Ruhr, Germany)

FROM the facts reported by the authors in their paper they have been able to give a brief survey of the effect on galvanized coatings of certain metals present in the zinc bath, in concentrations up to 1 per cent.

Tin has no effect on coating thickness or on the formation of zinc-iron alloys. The ductility of the coating is slightly affected but its adhesion during deep drawing is still good. The tendency to form wet storage stain remains unchanged while atmospheric corrosion resistance is reduced by about 10 per cent irrespective of the amount of tin present.

Cadmium is similar to tin in its effect on coating thickness, ductility, deep-drawing qualities and the formation of iron-zinc alloys. Small amounts of cadmium slightly inhibit wet storage stain formation, while atmospheric corrosion resistance is greatly improved.

Copper reduces coating thickness in proportion to the concentration, although the formation of zinc-iron alloys does not seem to be effected. Ductility and coating adhesion during deep-drawing are adversely affected, although there is some improvement at copper contents above 0.3 per cent. Additions of copper greatly increase the resistance of the coating to atmospheric corrosion and probably also reduce its tendency to form wet storage stain.

Aluminium rapidly decreases coating thickness to a limiting value obtained with a concentration of 0.2 per cent. The decrease in coating thickness is related to the inhibition of zinc-iron alloys : the effect is noticeable at 0.02 per cent Al, a thin layer of alloy remains at 0.06 per cent Al, and none can be detected at 0.08 per cent Al. Coating adhesion during deep-drawing operations and ductility are improved with aluminium additions up to 0.3 per cent, while further additions effect a decrease in these properties.

In proportion to its concentration, aluminium increases the tendency to wet storage stain. This effect was noticeable at 0.06 per cent Al, but was still only slight at 0.15 per cent Al. Atmospheric corrosion was greatly increased by aluminium additions and reached a maximum at a concentration of 0.4 per cent Al. As such additions also result in a decrease in coating thickness, the life of such a galvanized coating must be greatly reduced.

DISCUSSION

DR. ELEMER VARADY (Instituto Italiano del Piombo e dello Zinco) asked Mr. Souske to explain the fact that, as shown in illustrations, there was a possibility of producing a heavier coating than normal by the addition of aluminium to the bath in given small quantities ? Mr. Souske perhaps would be able to say on the basis of what series of tests he had been able to observe this fact, and the particular temperature, dipping time, and so on.

Perhaps Mr. Cameron would give some explanation or criticism of this phenomena in connexion with his theory on the activity in the various phases, and also apply to this practical example the principle of reactivity of the zinc-aluminium and iron elements in the galvanizing process. He knew that Mr. Cameron had brought a lot of interesting material with him and that he would have something to tell them on the effects of agitation, of quenching, and saturation of the bath with iron. He also thought that they would be able to ask Mr. Radeker to the rostrum and he would be able to tell them whether he had found something on the influence of aluminium and how he could justify this same phenomenon found by Mr. Souske and explained by Mr. Cameron, on the basis of his research results. Also Mr. Sebisty would perhaps be able to contribute to the discussion especially if he thought it necessary and advantageous to continue research into the use of aluminium.

Variation with Coating Thickness

MR. D. I. CAMERON (John Lysaght (Australia) Pty. Ltd.) said that the photomicrographs in the paper showed the variation in concentration of iron and zinc as one went from the base through the coating. He would show some slides of photographs taken with the electron microscope showing the alloy crystals that formed at discreet places on the surface of the steel base. There was nothing to see on the surface between these crystals. This was additional confirmation of the conclusions given in the paper. These were the final long time structures which were controlled by the aluminium, provided one had sufficient aluminium, sufficient agitation, and avoided the delays during cooling which in certain circumstances could give rise to the very rapid transformation to a zinc-rich alloy structure which thereafter took command of the situation, grew rapidly and continued to dissolve at its surface in the bath, drawing down a large amount of dross in the rest of it. He wished to thank Dr. Varady for his presentation of the paper as a whole and the opportunity of presenting this additional information. They had taken a photograph of one of the hexagonal crystals in the electron scanning microscope and they had photos of the same areas as seen on an electron microscope, then in terms of zinc only, then aluminium only, and then the iron, which presented a fascinating picture.

MR. ROBERT GLOOR (Verzinkereiwerke Kummler & Matter A.G.) offered a warning to the effect that the conditions for sheet and wire were vastly different to those applying for example, to section galvanizing.

MR. RAYMOND C. BELL (Consolidated Mining & Smelting Co. of Canada Ltd.) said that the papers and those which had gone before, including the work of Dr. Bablik and his co-workers, gave a large amount of information on the effect of the various elements in the zinc bath — effects both singly and in combination — and although the results that the various investigators had reported were not in complete agreement, nevertheless he believed that they revealed a good deal of the behaviour of these various addition elements as they affected the structure and the properties of the galvanized coating, both in the continuous-run type of galvanizing and also for the jobbing type of galvanizing.

When one considered the impurities in the zinc bath it was striking that, apart from aluminium (which, was only really applicable in certain types of galvanizing) and apart from lead, which was added for certain practical reasons, none of the elements stated thus far contributed any significant improvement to the coating, except perhaps with respect to coating appearance. Indeed, where they had an effect at all most of the effects were deleterious and rather objectionable. Even the improvements in coating appearance were not gained without some loss in other properties. It was a very valuable type of information to define the range of compositions which could be safely used without adversely affecting the coating properties. He believed that most of them would really like to find some element or elements which could be added to the zinc bath to contribute some rather outstanding property to the coating or some outstanding ability to put the coating on more easily. One such improvement, for example, might be to find some vastly improved corrosion resistance. He had noted with some interest that one paper, by Radeker, Peters and Friehe, did give some indication of improved corrosion resistance. Also of interest were the results that had been reported recently before the American Hot Dip Galvanizers' Association in which the workers there reported that the addition of magnesium in a galvanized coating in the general range of 0.04 to 0.05 per cent magnesium produced a marked improvement in corrosion resistance, and the workers claimed up to 50 per cent improvement, taking an average figure — apparently without any otherwise harmful effect upon the mechanical properties and also apparently without causing too much difficulty in the galvanizing operation.

Aluminium and White Rust

MR. HAROLD EDWARDS (John Summers and Sons, Ltd.) said that Sebisty and Palmer had stated that storage stain susceptibility tests demonstrated that "white rust" corrosion was dependent to a major degree on the presence of aluminium in the coating. Radeker, Peters and Friehe in their paper stated that in proportion to its concentration aluminium increased the tendency to wet storage stain, and this effect was noticeable at 0.06 per cent aluminium but was still only slight at 0.15 per cent aluminium. Atmospheric corrosion was greatly increased by aluminium additions and reached a maximum at a concentration of 0.40 per cent aluminium. Referring to the paper by Wilcox and Dismukes, they stated that comparisons of aluminium containing an aluminium-free sheet gave some quantitative support for the often expressed view that white storage stain was more severe on continually galvanized strip which usually contained aluminium in the coating. A question had been asked on this matter and he did not think it was answered, but the evidence would appear to be definite. But the statements should be received with some reserve, for considerable quantities of such coatings were distributed without criticism

nowadays, and under some conditions the effect of aluminium had not been found. He wished to ask Mr. Sebisty or one of the other authors if they had any fundamental reason why the aluminium had this effect on the galvanized coating.

Also in the paper by Sebisty, in which it was mentioned that it had been demonstrated that it was possible to produce by conventional sheet galvanizing methods coatings which had properties similar to those of continuously galvanized strip, there was no mention of difficulties of maintaining controlled aluminium contents when flux was used.

AUTHORS' REPLIES

MR. J. J. SEBISTY (Department of Mines & Technical Surveys, Mines Branch) said that there was a supplementary report to the paper which listed all the voluminous data collected and also described the statistical treatment of the data. Should anyone care to receive a copy of this he would be only too happy to forward it.

As regards further tests on the use of aluminium and just how it could be used to improve the control of coating thicknesses and so on, there was nothing further planned in this direction but they did have another programme in progress at the present time which was concerned with additions of inter-elements and less common elements not normally found in galvanizing baths. This was really directed along the lines suggested by Mr. Bell ; in other words, they were looking for something which might give them an improvement in the coating thickness. The goal of the work was to produce thicker coatings that would have better ductility and adherence.

Copper had a particular and quite pronounced effect in the development of the iron-zinc faces, as they had shown in their paper. The variation in the structure from the typical structure to the granular type could be seen. The copper did alter the time-factor relationship quite considerably, because this granular type of structure appeared at a lower temperature than when copper was not present. Metallographically this was the principal effect noted on the copper. Copper did have quite a serious effect. Mr. Bianchini did not mention this but it could be a seriously detrimental effect, particularly in strip coatings, and he was fairly certain that this could not be tolerated in this type of application. He could not reply to his statement that up to 0.8 per cent copper improved the corrosion resistance in salt-spray tests. Their own particular test was concerned with dross formation and they were tempted to evaluate this by two different tests, one of which was a humidity test and the other a water film test. Both of these were essentially stack tests. The appearance of the coatings after these particular treatments could be treated visually in order to establish just what the effects were, so he could not offer any comments on just what might happen in salt-spray tests. They had never done them in this particular work. Dr. Edwards also had referred to this white rust problem. They had not studied the mechanism of what was involved where aluminium was concerned, and just why this increase in white rust steaming out of the white rust formation occurred. Dr. Edwards had mentioned that there was apparently no problem in this direction. That was perhaps a little far-fetched. It seemed to him that this was one of the principal concerns of strip galvanizers, the so-called white rust formation which might develop in transportation and so on and shipment of the finished product, due to the condensation problems which might occur in the type of storage involved. In this connection it should be pointed out that their tests were done on the bare sheet as opposed to the chromate treatments which were generally applied to strip coatings.

MR. R. SOUSKE (Ste. Zinc et Alliages), in reply, said that in the report as presented, and which they had had an opportunity of examining, they were dealing particularly with aluminium concentrations which were generally much lower than those normally considered. They had then carried out tests and found that the aluminium content of 100 grammes per ton of zinc would lead not to a diminishing of the deposit but an increase which could go up to 20 per cent. This was under normal galvanizing conditions, *i.e.*, a temperature of 450°C, and immersion periods which were also normal, *i.e.*, varying from 20 to 60 seconds. This increase in weight was also found in the metallographic tests they had recently carried out, and which indicated the formation of the layer which was not affected by either the temperature or the aluminium content. If they considered higher aluminium content, such as 0.02 to 0.05 or 0.1 per cent, which were also used, they realized immediately that the δ layer had slowed down the the time of immersion as a result of increasing the immersion temperature and sometimes came to almost zero thickness. They were also able to determine that it was possible to obtain a coating of very cohesive quality, and in certain conditions it was approximate to those obtained in the fabrication of galvanized sheet. They had tested these conditions through micrographs and through various tests carried out under the Erichsen process. The temperature of galvanizing was increased to 460°C and the period of immersion reduced to 10 seconds. The micrograph indicated a similar coating and the Erichsen test showed cracks of similar width, *i.e.* 1 micron. In the study they had finalized a

cohesion test of zinc on steel by using the Erichsen method which they had modified. They had measured the depth so as to obtain the resistance of the steel, and they also had tried to measure the penetration which did not involve molecular changes. They were able to measure from 1 to 20 microns the cracks which were produced in the coating. It was possible to suppose that when examined with the naked eye there appeared to be cracks and the coating seemed to be fully adherent. They had found in this series of tests that in all cases there were such cracks but in the case of excellent adherence there was considerable cracking and in the case of poor adherence there were fewer cracks but of greater width, sometimes accompanied by certain flicking up of zinc particles, and the disadvantage of this process was that it must be immediately photographed because the specimen changed in the course of time and certain cracks might turn up which were not noticed at the time of testing. It was felt that this type of test was of interest since they could in this way measure the adherence of zinc on the steel.

DR. W. RADEKER (Phoenix-Rheinrohr A.G.) in reply, said that the tests he conducted were largely determined by the anxiety expressed by his colleagues, who on the one hand wished to find a cheap source of galvanizing, and on the other hand a high quality type of galvanizing. As a result, his tests were based on certain practical principles rather than purely being of scientific concern. From the metallurgical point of view he had little to say as regards the effect of aluminium, and all he could say would be based on the somewhat primitive approach of the semi-scientist. All the additions of alloys to zinc had three-fold repercussions. First of all, they had an influence on the zinc-iron reaction, and it would appear that in this context the affinity of aluminium to iron was so great that there was some inhibiting layer which corresponded to the properties of aluminium and prevented the diffusion of iron to zinc. This up to a certain limit produced a diminishing of the so-called intermediary layer. The thickness of the zinc coating seemed to be largely influenced by the viscosity of the zinc itself, and if they were to apply a strict zinc-iron alloy they had a layer of heavy viscosity which had an effect on the iron base and did not run off and as a result made this thick coating possible. When this layer was lacking, as in the case of the aluminium addition, they found a zinc layer of a thickness corresponding to the original viscosity of the zinc before rigidity or after removal. The effect of the copper, which on the basis of his experiment also had an inhibiting effect on the coat, seemed to be due to the fact that copper may somewhat diminish the viscosity of the molten zinc. The other alloys which were lesser in influence seemed to provoke no effect of viscosity. The addition of alloys had an influence on the reaction of iron and zinc, on the viscosity of the zinc and ultimately also — this had been tested by them — on the corrosion resistance of zinc, and here the alloy was bound to be secondary in importance. Zinc had good corrosion properties since its corrosion product was a useful coating applied over the zinc which then protected the zinc against further corrosion. When alloy elements were included in this protective coating it might be improved or else there would be a deterioration, and it seemed a fact that the aluminium oxide particles which were incorporated into this protective layer were unfavourable and the corrosion velocity of the aluminium alloy seemed to be greater than that of the pure zinc. If, therefore, aluminium was incorporated in the bath they produced a thinner coating and good folding capacity which might be beneficial to the consumer. However, if the corrosion resistance was reduced and the thickness increased this was a disadvantage to the consumer.

MR. D. I. CAMERON (John Lysaght (Australia) Pty Ltd.) said that Mr. Gloor had quite rightly pointed out that the general galvanizers had entirely different problems in many ways from the sheet and strip galvanizers. This was true, but it was in the hope that they might find understanding of the variations that could occur at low aluminium concentrations that he had done this work with a wide range of concentrations up to 10 per cent.

The first tentative identification of the phases, even at 2½ per cent aluminium, as being δ and ζ, were made as a result of micro-hardness measurements carried out on the individual phases. They had from time to time attempted chemical analysis but it was almost impossible to get a sample on which one could reply because many of these phases so far could only be formed as isolated crystals in a coating, and there was no easy way to dig this out when once one had got it. Such analyses as were done were confirmed by the micro-probe analyses.

Session 6b

Chairman : MR. CH. VAN KEMPEN
(Johan Vis and Co., N.V.)

The Influence of Steel Composition on the Attack by Molten Zinc in the Parabolic Range

D. HORSTMANN
(Max-Plank-Institut für Eeisenforschung, Germany)

IRON and steel are attacked by molten zinc according to two different time laws depending on the temperature. At low and high temperatures the rate of attack decreases parabolically with time, whereas at a

given temperature in the intermediate range (around 500°C) the rate of attack is constant and the iron loss increases linearly with time. In a well-controlled galvanizing process the bath temperature is regulated so that it falls within the lower parabolic range (up to approximately 460°C.)

Extensive investigations have shown that the attack of molten zinc on iron is considerably affected by the presence of alloying elements in the iron. Simple and generally valid laws have been established which determine the extent of the attack in the parabolic range. It has been found that the values of a_0 and U, which determine the effect of temperature on the rate of attack, vary with the concentrations of alloying elements in a characteristic manner. When the alloying element is present as a heterogeneous precipitate in the iron, both values decrease linearly with increasing alloy concentration. When the alloying element forms a solid solution in α-iron, the value of $\sqrt{\frac{1}{a_0}}$ increases and the activation energy U decreases linearly with concentration expressed in atom-per cent, provided the concentration is small. The increases and decreases in these values for specific elements have been found to depend on their atomic structure and on their solubility in the α-iron.

The results obtained by the authors enable the extent of attack by molten zinc to be calculated, after a given time and at a given temperature within the parabolic range, for a particular alloy concentration.

Conditions Determining the Formation of Dross in the Hot Galvanizing of Ferrous Material with Particular Reference to Carbon Steels

R. SANDRINELLI and V. SALEMME
(Dalmine S.p.A. Milan)

THE hot galvanizing of ferrous material in certain instances gives rise to significant losses of both iron and zinc in the form of dross. Dross consists of a matrix rich in zinc, in which crystals of the iron-zinc compound are embedded, becoming detached from the iron base and accumulating at the bottom of the pot from which they must be removed periodically. Increasing amounts of carbon intensify the attack on iron and the authors summarise their work in the following way :

(a) Steels with low carbon contents, and silicon contents below 0.10 per cent can be galvanized with an iron loss, and therefore dross production, that can be kept very low provided the temperature does not exceed 470°C. The influence of manganese below 0.40 per cent is significant.

(b) Steels containing 0.11 per cent C, 0.15 per cent Si and 0.40 to 0.50 per cent Mn would be rapidly attacked by zinc if the temperature reached 480 to 490°C. Below 480°C the attack would be limited but it would still be greater than that found with Si and Mn contents at identical temperatures.

(c) When the carbon content reaches 0.22 per cent, Si 0.30 to 0.40 per cent and Mn a maximum of 0.70 per cent, the attack becomes severe at temperatures slightly above 460°C.

(d) Because of the accelerating effect of silicon, steels killed with aluminium and silicon should show a much lower resistance to attack than steels killed with aluminium only, and a substantially greater resistance to attack than steels killed with silicon only. Rimming steel, since it contains no silicon, should therefore show favourable behaviour. In the galvanizing of pipes produced from killed low-carbon steel the amount of dross formed was on an average two and a half times greater than that formed when galvanizing rimming steel pipes.

Consequently in order to reduce dross losses, and hence zinc consumption, attempts have been made to reduce the immersion time and also the bath temperature (to 350°C). At the same time the addition of aluminium has been carefully studied in order to determine the optimum content which would give the most uniform layer of zinc of adequate thickness compatible with the degree of roughness on the surfaces which are to be galvanized.

DISCUSSION

MR. D. I. CAMERON (John Lysaght (Australia) Pty Ltd.) said that arising out of this work and Dr. Horstmann's previous work he wondered whether he might suggest a possible controlling mechanism for the parabolic rate of attack, and would like to know whether Dr. Horstmann would consider that this might fit in with his results. There were several surprising things about this parabolic law. It was so simple that there must be, he thought, a single controlling factor. It could not be the ζ layer because the parabolic region was not only at the lower temperature where ζ was possible. It corresponded also to the upper temperature region where ζ did not exist. The ζ layer was not a controlling factor. If it was the thickness of the δ layer the fact remained that there was a difference in the form of δ that occurred when one went from the lower temperature region to the higher temperature region, and yet there was no change in the parabolic law. In addition to this he wished to draw attention to the fact that the δ layer itself apparently was the region of greatest change near the base, and that the total thickness of the layer seemed to be incidental and not a controlling factor. If it was not the ζ or δ neither could it be the γ because the γ could not exist in the higher temperature range either. So that they were looking for a simple controlling factor that would apply in spite of all of these, and he suggested that it might possibly be associated with those figures he had shown earlier suggesting diffusion of zinc into the iron. It would not then be surprising if other elements that could dissolve in the iron should have effects that were proportional to their ability to saturate the iron ; and, if they were dealing with a diffusion effect such as zinc in iron, again it would not be surprising if there were some relationship between what one found and the periodic table.

In this connection he wished to draw attention to some work done by another of Dr. Horstmann's colleagues at the Max Planck Institut, Dr. Schenk, who had shown that the solubility of carbon in iron was controlled by other elements in a manner that could be represented in terms of the periodic table very similar to Dr. Horstmann's Fig. 4.

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Overseas Review

(*Continued from page* 450)

Plating and Pickling

The chemical removal of metal or metal oxides by pickling, or by the more fashionable controlled etching, seldom makes the headlines in finishing literature. An interesting application of this controlled etching is in the production of printed boards for circuits, in which copper foil is permanently bonded to a non-conductive laminated panel. The pattern is then printed on the foil using a chemical resisting ink and the unwanted parts of the copper foil are etched away, leaving the circuit. Ferric chloride solutions are used for this and the correct concentration is important to ensure that neither too much copper is removed nor, on the other hand, does the reaction proceed too slowly. Greer[5] has given details of an automatic system for controlling these additions of ferric chloride, using a special reference electrode in a system based on oxidation-reduction potentials.

Interest in iron plating comes in cycles and from a recent article by Clark[6] it is suggested that we may again be due for increased activity in this field. It is finding some increasing application in the electronics industry and there is some evidence that iron may be used to advantage instead of copper as an undercoat for nickel/chromium plating.

Protective Coatings

Lipinski[7] has published some interesting results on so-called organic conversion coatings for aluminium surfaces. These films, which are claimed to improve paint and adhesive bonding, have a low film weight, chemical polarity and a cathodic protective nature. They are stated to replace the natural oxide layer and to be markedly superior to phosphating, chromating or anodising.

Depending upon the method of application, the time required to form the coatings is from 15 seconds to several minutes at a temperature of 160 $\pm$ 10°F. Film thickness is believed to approach mono-molecular dimensions. They are colourless, do not appreciably alter the appearance of aluminium surfaces and it will be interesting to see how far they encroach on the field already filled by phosphate and chromate treatments.

Still on the subject of aluminium, Smits[8] has described a new test which has recently been developed for measuring the abrasion resistance of anodized surfaces. It is particularly designed to simulate the damage caused by a single stroke such as that inflicted by a flying pebble or stone on a motor-car bumper. A series of scrapes with a pointed tool are made at constant speed on the test surface. Each scrape is at a different location and small increments in weight are added between each individual scrape until penetration is effected in one strike, as indicated by the completion of an electrical circuit. It is claimed that this testing mechanism is also applicable to lacquered, painted and even vitreous enamelled surfaces.

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AUTHORS' REPLIES

DR. HORSTMANN said that he had not found evidence of solubility of zinc into iron. This did not mean to say that it was not present.

As regards the time when two or three elements were simultaneously present, and whether they had any effect upon one another, all atoms behaved as if others were not present. The manganese atom in iron, for instance, which was relatively far removed from the aluminium or sulphur atom, did not know that in its vicinity another atom was actually present. If he were to use his equation—and this applied only to small concentrations—he could calculate new constants from these values by adding these various components and then obtain a new constant.

The linear time range was based on the fact that the ζ crystals no longer formed at temperature below 530°C. *i.e.*, temperatures where the ζ phase was still a constant one. The nuclear growth was so small that this layer could no longer form. This led to the fact that the δ layer was in immediate contact with the zinc coating, and as a result had a partial diffusion which led to the alloy layer. It was also the case with the presence of the aluminium in the galvanizing bath. Mr. Cameron had pointed this out in his own report. This temperature range of high linear attack which increased in time was always within this range of between 530°C down to 475°C more or less. In the case of silicon it could go down to roughly the melting point for zinc.

(*To be continued*)

FULLY AUTOMATIC SURFACE TREATMENT PLANT INSTALLED FOR FRENCH CAR FIRM

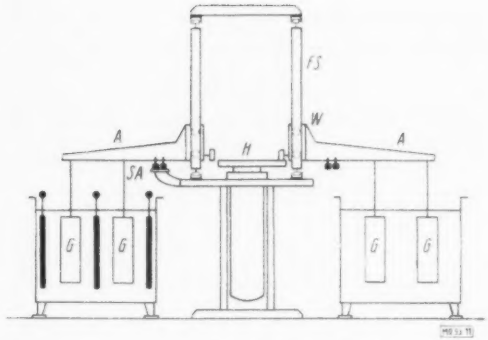
Processes Include Bright Dipping, Anodizing and Dyeing of Aluminium

THE fully automatic plant for the surface treatment of aluminium described in the present article was supplied to a well-known French motor-car company.

The plant in question is of the so-called return-type with a length of 42.5 m. (139 ft. 5 in.), a width of 4.4 m. (13 ft. 3 in.) and a height of 4.65 m. (15 ft. 3 in.) and has been designed for an output of approximately 1000 radiator grills and 2000 rear-lamp fittings per 18 hours.

A front view of the automatic plant is shown in Fig. 1, whereas Fig. 2 represents a sectional view of the machine.

The automatic lifting and conveyor system is located between the two rows of tanks, but is completely independent of them. Transport carriers (W) running in vertical guide rails (FS) are each fitted with a flight bar (A) on which racks (G) with work are suspended. Guide rails (FS) are fixed at their top and bottom ends to drive chains and are thus transported forward by these chains *via* a reduction gear motor drive. Forward traverse is intermittent and correlated to the lifting motion of the lifting beam (H). Flight bars (A)—



incorporating current collectors (SA) at their free ends—are fixed to transport carriers (W) in an insulated manner. The cathode contact slipper tracks are mounted on the main steel structure—that is to say in a parallel position to all current-carrying baths.

The racks are lifted and lowered by the lifting beam (H) running on suitable guides arranged inside the steel structure. The cycle time—in this case being 90 seconds—is pre-set by a timer which starts the lifting motion—*i.e.* all transport carriers are being lifted at the transfer points of the automatic plant. When the carriers have reached their top position, a limit switch is actuated, stopping the lifting motion and simultaneously starting the forward traverse. All lifted carriers are thereby transferred over the partition walls of the treatment tanks, and all carriers—still in lowered position—in multi-cycle tanks—are advanced within the tanks.

The forward traverse motion is controlled by a special cam disc which stops it after one turn and simultaneously starts the lowering motion, that

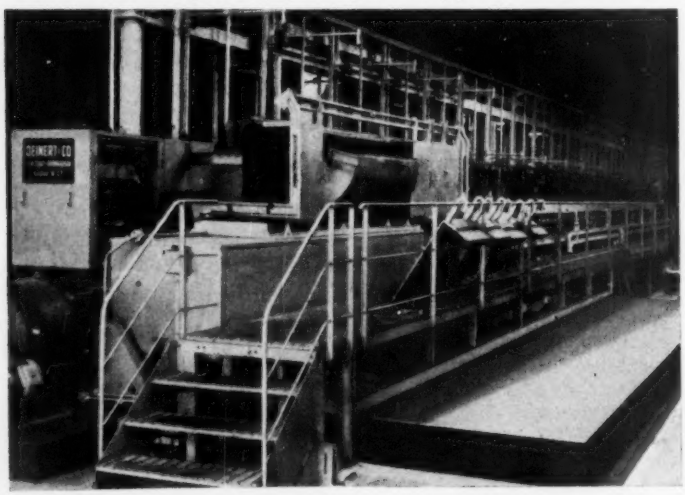


Fig. 1.—(left) Front view of the automatic plant.

Fig. 2.—(above) Sectional breakdown of the machine.

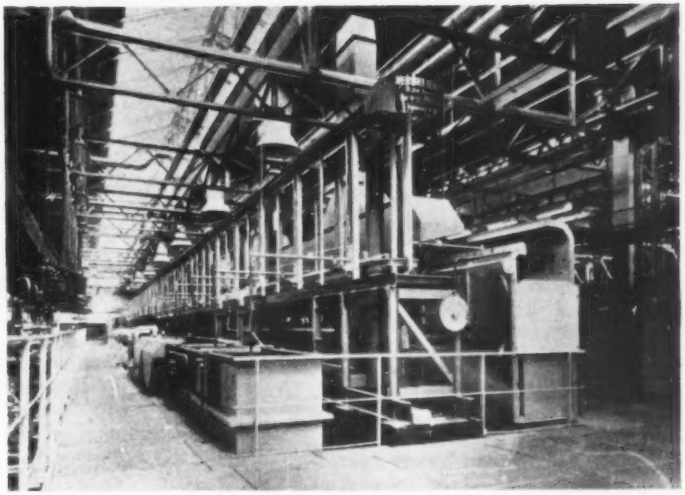


Fig. 3.—View of the plant emphasising its length of this particular installation.

is to say the carrier that have previously been transferred over the partition walls are now lowered into the following tanks. The different motions *viz.* lifting—forward traverse and lowering are safely interlocked so as to eliminate completely the possibility of overlapping. Because of its special design this transport system lends itself for many different applications and leaves room for mounting the most varied auxiliary equipment.

The most difficult problem was however to fit the required bright dipping processes into the automatic operating sequence, since :

(1) Bright dipping time is very short and differs from the cycle time for the remaining operations. Besides, the bright dipping time must be changed to suit the efficiency of the solution at any stage, *i.e.* the immersion time has to be extended with increasing age of the bath.

(2) Rinsing has to take place within at most 5 seconds after bright dipping to avoid etching. Moreover, rinsing has to be sufficiently intensive to ensure speedy and complete removal of any adhering traces of the elelectrolyte or at least adequate dilution of the same to eliminate its etching effect.

This rinsing problem—and consequently bright dipping itself had not found a satisfactory solution so far for automatic operation. A new device—incorporated in the plant under review—has now provided the answer to this problem—and rinsing does in fact take place within at most 5 seconds after bright dipping.

A new process (German Patents pending) has been applied for bright dipping. The solution is operated on the basis of phosphoric-nitric acid. A working temperature of 90 to 110°C (194 to 230°F) is recommended. The bright dipping time is between 45 and 60 seconds. Parts of alloy type A 9 G 3 (conforming to Al Mg_3 on a 99.99 per cent Al basis) are being brightened in the plant concerned which incidentally is also suitable for bright-dipping with fluoride solutions.

The bright dip tank is made of 18/18 Cr-Ni-Mo steel and provision has been made for indirect heating by hot water at 160°C. (320°F.) and Shell-Turbo Oil as heat conductor. The tank has been fitted with suitable fume-extraction units made of p.v.c. The resultant fumes are absorbed by a fume washer. An agitator has been provided to ensure constant bath circulation.

The treatment sequence is as follows :

(1) Alkaline clean at 35 to 40°C (95 to 104°F.)
(2) Warm rinse
(3) Cold rinse
(4) Chemical bright dip
(5) Spray rinse
(6) Cold rinse
(7) Nitric-acid dip
(8) Cold rinse
(9) Anodic oxidize for 22 minutes
(10) Cold rinse
(11) Cold rinse
(12) Dyeing at 50 to 60°C (122 to 140°F) for 4 minutes
(13) Spray rinse
(14) Cold rinse
(15) Seal for 20 minutes
(16) Nitric-acid dip
(17) Cold rinse
(18) Warm rinse
(19) Dry-out
(20) Unload

(*Continued in page* 464)

A.D.A. Anodizing Conference

(*Continued from page* 454)

The paper on electrical applications by LEE makes some valid and relevant comments on the potentialities and problems associated with the use of anodized windings. It is perhaps a pity that they dealt solely with windings which require a specialized continuous strip or wire plant. There are a number of applications where the insulating properties of the anodic coating are used to advantage on electrical components and machinery. This field is not mentioned in either this paper or that of STEPHENSON.

CAMPBELL'S contribution on applications of hard anodizing comes from a pioneer in this field. It provides an impressive list of applications, a useful section on practical problems arising from the specifying of hard anodic finishes, limitations of the process, methods of finishing hard anodized coatings, as well as a useful review of the anodizing processes in commercial use.

Final Technical Session

The last set of papers provides an impressive account of the many finishes which anodizing can provide. HENLEY'S paper provides a useful catalogue of many " tricks of the trade " used to provide various finishes, but this is still an incomplete list. In a more specialised field the paper of FOX-WILLIAMS and WATTS is valuable for dealing with some aspects of architectural colour anodizing which are infrequently discussed. Many will welcome the table giving an approximate breakdown of the items contributing to the cost of producing an architectural anodic coating. In particular, it indicates clearly the higher cost of providing mechanical pre-finishes compared with chemical. This should be more widely used by A.D.A. and its members in pointing out to architects the relevant £. s. d. of producing the more exotic finishes. The comments on colour in architectural work, and also on protection and care during transit and on site also merit study by all concerned.

The remaining paper in this sessiod described the whole range of techniques associated with the production of multi-colour finishes. This has always been regarded as a highly specialized art, with each company having its own carefully guarded " know-how." Against this background it is a real landmark in anodizing history that not only should so much of the relevant techniques be detailed in a published paper, but that in the same paper the author should demonstrate how to marry art with science and adpt the process to an automatic anodizing and dyeing unit. Here is proof indeed that the mass production of even the most complex and exacting finishes can be competently and economically tackled by the industry.

* * *

There is no doubt that the Conference was a success, and all concerned with it should be well satisfied. It can be regarded as a landmark in the history of anodizing in this country. A full volume of papers and discussion is to be published by A.D.A. and it is to be hoped that it will appear quickly. Without doubt it will be a publication to which frequent reference will be made.

Automatic Surface Treatment Plant for French Car Firm

(*Continued from page* 463)

(21) Deoxidize
(22) Cold rinse

Operation No. 15 " Seal " is effected by boiling water.

The parts processed in this plant are claimed to meet the most exacting demands and costs are kept within reasonable limits owing to the high regenerating power of the bright-dip solution.

The plant was designed and manufactured by Deinert & Co., Spezialbetrieb für Galvanotechnik, Bernhausen bei Stuttgart.

SURFACE TREATMENT AND PROTECTION OF METALS

Special Lecture Course at Enfield Technical College

A special series of nine lectures dealing with the problems encountered in the surface treatment and protection of metals, and techniques of applying these treatments and evaluation of the results achieved, has been arranged by the Enfield Technical College. The course will be suitable for professional engineers, metallurgists and chemists concerned with this field, and will be held on succesive Monday evenings at 7.00 p.m. commencing on January 15, 1962. Applications should be made as soon as possible to J. E. Jones, Head of the Department of Pure and Applied Science, Enfield Technical College, Queensway, Enfield, Middx.

FINISHING NEWS REVIEW

INTERNATIONAL STUDENTS COMPETITION

THE North-West Branch of the Institute of Metal Finishing are organizing an International Students Competition — with an age limit of 25 years. The subject matter is left to the discretion of the author, the only proviso being that it should be allied to the art and science of metal finishing. Papers submitted may vary from academic to practical, which will allow the apprentice at shop floor level and the college student to participate on equal terms. The competition is open to all students whether or not they are members of the Institute.

Judging will take into consideration the following points: (*a*) Presentation; (*b*) age; (*c*) education and training; (*d*) originality; (*e*) clarity of statement, and (*f*) importance of subject as allied to present-day metal finishing technique.

Prizes will be awarded as follows : (1) Best all-round paper ; (2) best organic paper ; (3) best paper on electro-chemical, chemical or allied subject (including polishing, cleaning, pickling, etc); (4) best practical paper, and (5) best paper submitted by a student under 20 years of age.

Prizes valued between £5 and £10 will be awarded in the form of vouchers to enable winners to select books, apparatus or equipment to their own choice. Winners will be notified by March 1, 1962, and papers will be read in abstract form at the Branch meeting to be held at the Engineers Club, Albert Square, Manchester on April 5, 1962, and the prizes will be presented at that meeting. Winning papers will be published in the technical press if the required standard is reached.

Further particulars and entry forms may be obtained from the branch Hon. Secretary, Mr. F. Spicer, " Suffield Cottage " Moorhead, Gildersome, Nr. Leeds.

New German Hydrogen Peroxide Plant

THE Elektrochemische Werke München, A.G., which earlier this year became a member of the Laporte Industries Group, is to construct a large-scale plant for the production of hydrogen peroxide by the Laporte autoxidation process, operated in the U.K. by Laporte Chemicals Ltd. at Warrington.

The new German plant will be at the E.W.M. Works at Höllriegelakreuth, near Munich, and will augment the existing electrolytic process for the production of hydrogen peroxide and persulphates.

Extensive planning activities are well advanced and construction of the plant will be started in the near future.

Epoxy Resin Price Reduced

CONTINUED expansion in the production of 'Araldite' has enabled CIBA (A.R.L.) Ltd., to announce further reductions in the prices of their epoxy resins. Reduction has been made in most products of the 'Araldite' range, and full details are available from CIBA (A.R.L.) Ltd., Duxford, Cambridge.

* * *

THE price of all liquid and solid Epophen epoxide resins, manufactured by Leicester, Lovell and Co. Ltd., supplied in bulk quantities will be reduced by 6d. per lb. These price cuts are made possible by increased production and economies in manufacture.

Third International Metal Spraying Conference

AFTER the success attained in the two former international Metal Spraying Conferences held at Halle (Germany) and Birmingham (Great Britain), the Spanish Institute of Welding has been charged to prepare the Third Conference on Metal Spraying and allied subjects, to be held at Madrid from May 21 to 25, 1962.

The Executive Committee has established the following index of subjects to be dealt with ; other matters may be added :

1. The fundamental science of metal spraying.
2. The design of metal spraying tools, electric and gas.
3. The choice of metal deposits.
4. Commercial uses of the process.
5. New developments.
6. Economic aspects.
7. Health hazards.
8. Flame spraying for hard facing.
9. Flame spraying of ceramics.
10. Flame spraying of plastics.

Official languages will be French, English and Spanish and the enrolment fee will be 1,700 Ptas. per delegate and 340 Ptas. per person accompanying delegates.

For detailed information apply to the Institute de la Soldadura (Secretariat of the III International Metal Spraying Conference), Serrano, 144-A, Madrid-6, Spain.

Roto-Finish Ltd. Branch in Scotland

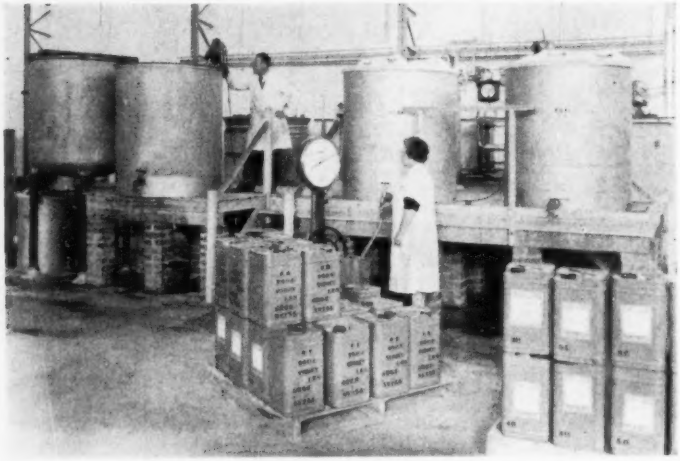
ROTO-FINISH Ltd. have opened a branch factory at Cumbernauld Estate, Glasgow.

Floor area is 3,000 sq. ft. and the factory is situated on the new industrial estate, 12 miles from Glasgow.

Roto-Finish area manager for Scotland, Mr. J. Jamieson, is in overall charge. The company's barrel and vibrafinishing machines are installed for demonstration and for sample processing purposes. In addition this Scottish branch will hold stocks of the company's materials in order to be able to give immediate service to industry in the Scottish area.

NEW FACTORY TO SERVE METAL-FINISHING INDUSTRY

Harshaw Chemicals Open New Facilities at Daventry



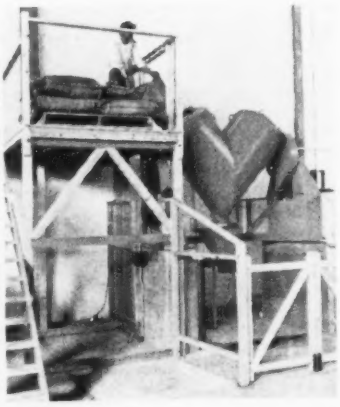
(Above) : Plating tanks in the demonstration room where customers can see any normal plating process reproduced. Shown in this photograph is Mr. C. C. Postins, chief chemist.

(Left) : The liquid addition-agent plant.

(Below) : Newly-developed American-type twin-shell liquid-solid blender for cleaning compounds.

ESTABLISHMENT of a new £100,000 factory built to serve the metal-finishing industry was celebrated at Daventry recently by Harshaw Chemicals Ltd., manufacturers of chemicals for electroplating. A wholly-owned subsidiary of the Harshaw Chemical Co. in the U.S.A., the British firm was established in 1956 at Waltham Cross, Herts, to cater for the growing demands for the company's products, which include electroplating addition agents and cleaners ; the company also distribute nickel salts, anodes, etc., throughout the U.K. and Commonwealth countries. The new building includes modern offices, laboratories, and the works where the chemicals are formulated and made up.

The officials opening was performed by the Mayor of Daventry, Councillor L. E. Whitmee, in the presence of the president of the American company, Mr. Charles S. Parke, and other guests from the industry and the press.



New Films

IN London recently the Carborundum Co. Ltd., introduced three new additions to their already vast library of industrial films. Made by the company's own film unit, the new films, aptly named "The Winning Tip," "Heat in Harness" and "To be Precise," covered a range of applications in which refractories, abrasives and ceramics are used. "The Winning Tip" deals with development-cutting tools and shows how the use of ceramic-tipped tools produces excellent results with savings of both time and costs.

"Heat in Harness" surveys the demanding field of furnace refractories and shows some of the rigorous applications to which Carbofrax. Zircofrax and Millfrax tiles and bricks are subjected. Their resistance to high temperatures and to molten metal make them particularly suitable for roles in smelting and enamelling. Carboradiant chamber furnaces for bath enamelling are designed, built and maintained by the company's own technical staff with a minimum muffle life of two years.

SPECIAL DIVISION FOR VACUUM FURNACES

THE vacuum furnace activities of Efco Furnaces Ltd., will henceforth be handled by a new division with offices, design and manufacturing facilities at Sheerwater, near Woking in Surrey. Mr. M. J. Severs, B.Sc., A.M.I.Mech.E., formerly with the furnace department of The General Electric Co., Ltd., has been appointed technical manager of the new division and Mr. W. Kuyser, B.Sc., previously vacuum sales manager of General Engineering Co. (Radcliffe) Ltd., sales manager.

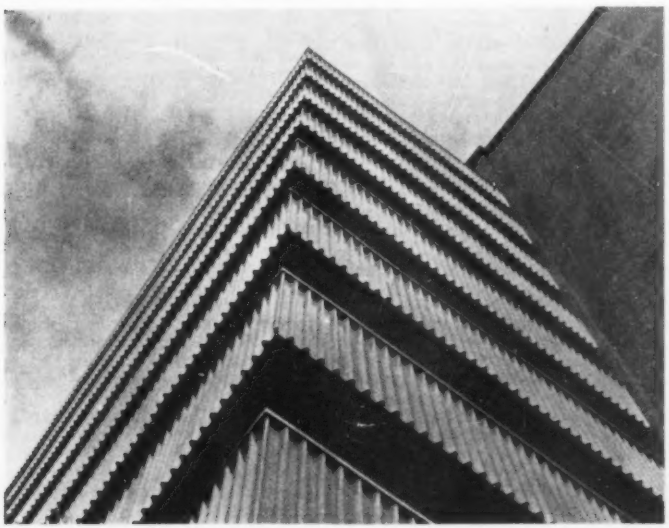
Progress for Labelling Scheme

AS part of the campaign for better chromium plating, The International Nickel Company (Mond) Ltd., promoted the scheme for labelling chromium-plated goods which are plated to British Standard Specification. Now over 200 manufacturers and platers have joined this scheme and the quality label is found on goods in shops and garages, and to explain the meaning of the label to the general public a comprehensive television schedule has been arranged.

ENAMELLED ALUMINIUM FOR AUSTIN CAR PARK

THE Austin Multi-Storey car park at Longbridge is believed to be the largest of its type in the world, and is designed for storing 3300 production cars awaiting delivery to the docks or to dealers.

A feature of the building is the cadet-grey enamelled aluminium balustrade which surrounds each floor to a depth of 4 ft. and fixed to a steel balustrade structure. In all, some 45,000 sq. ft. of aluminium sheet were used for this purpose amounting to about 17 tons in weight.



Revised B.S.S. for Anodic Oxidation Coatings on Aluminium

IN order to bring the specified properties and methods of test into line with current practice, the British Standards Institution has published a new edition of B.S. 1615, anodic oxidation coatings on aluminium.

In this new edition anodic coatings are classified by their thickness only, without the former reference to the type of electrolyte. The classification has been altered to allow new grades to be systematically incorporated. The standard introduces a 1-micron grade for infra-red reflectors and, at the other end of the scale, a 35-micron grade for special architectural purposes. The thickness test by stripping has been supplemented by a microsection method.

Sealing requirements are now specified by the standard. Effectiveness of sealing is tested by a sulphur dioxide/humidity method similar to the test on chromium-plated coatings for corrosion resistance specified in B.S. 1224.

Requirements for image clarity, corrosion resistance, leaching resistance and electrical breakdown voltage vary according to the use. Tests for such properties are described but the extent of testing or the performance is decided by agreement in each case.

Copies of this Standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

Protection for Railway Bridge

WORKING round the clock is a function of the Contract Division of The Ruberoid Co., Ltd. A recent example of this was at the Wolverton railway bridge where waterproofing of the bridge deck was carried out in 24 hours without completely halting traffic on the line.

The Ruberoid system of bridge waterproofing is suitable for all brick, masonry, ferro-concrete, prestressed concrete and steel bridge decks, as well as subways, aqueducts, etc., and consists of laminations of Pluvex reinforced bitumen sheeting or ruberoid copper lined bitumen sheeting bonded with Ruberoid compound and surfaced normally with brindle or quarry tiles.

TECHNICAL *and* INDUSTRIAL APPOINTMENTS

Mr. T. E. Peacock and Mr. A. C. Nicholson, joint managing directors of Laporte Acids Ltd., have been appointed directors of **James Wilkinson and Son Ltd.,** the Laporte Group company specializing in aqueous hydrofluoric acid and inorganic fluorine compounds.

Mr. Nicholson has also been appointed a director of **The Sheffield Chemical Co. Ltd.,** the other Laporte Industries manufacturing company.

Mr. J. Hill has been appointed secretary of Laporte Acids Ltd., James Wilkinson and Son Ltd. and The Sheffield Chemical Co. Ltd. He is also accountancy manager of these companies.

* * *

Geigy (Holdings) Ltd. of Manchester announce that the following have been elected directors as from 1 January 1962, while retaining their present appointments.

Dr. F. Buchmeier, deputy chairman and managing director, Ashburton Chemical Works Ltd. ; deputy chairman, James Anderson and Co. (Colours) Ltd.

Mr. H. Jones, deputy chairman and joint managing director, The Geigy Co. Ltd. ; director, Ashburton Chemical Works Ltd.

Dr. H. B. Knuchel, chief executive and secretary, Geigy (Holdings) Ltd. ; director, The Geigy Co. Ltd. and Geigy Pharmaceutical Co. Ltd.

Mr. J. A. Rodgers, deputy chairman and managing director, Geigy Pharmaceutical Co. Ltd.

* * *

Owing to the steady growth in orders for their spray painting equipment, **Atlas Copco (Great Britain) Ltd.** of Maylands Avenue, Hemel Hempstead, Herts, have appointed four more sales representatives.

Serving the London area will be Mr. A. W. Kingwell and Mr. C. A. Gammon, who will operate from the Atlas Copco branch office at 7 Gayford Road, Shepherds Bush, London, W.C.2.

Mr. W. Beaumont is operating in the Leeds area (office at Weaver Street, Kirkstall Road, Leeds 4) and Mr. H. Fellows in the Midlands area (office at 23 Lombard Street, Lichfield, Staffs.).

* * *

The following appointments are announced by **Stanley Works (G.B.) Ltd.**

Mr. Arthur G. Jones, general works manager becomes works director, and Mr. William R. Mills, general sales manager is now sales director.

Mr. Warwick M. Dingley has relinquished his seat on the board in view of his increasing commitments as director of Marketing in Europe for the whole of the Stanley international organization.

Mr. Ronald Shelton, product designer, is to head a new department responsible for the design and development of new products.

Mr. Robert Bradley, formerly chief planning engineer, has been appointed manager of the engineering department.

Mr. Laurence Ford, chief engineer, is leaving the company to take up a new appointment.

* * *

It is announced by **Detel Products Ltd.,** that Mr. Leslie Albert Greville Johnson has been appointed managing director.

He succeeds his mother, Mrs. Vivienne D. Johnson, who continues as director and secretary to the company.

* * *

Dr. Alexander Ross has been appointed European technical representative for **M. and T. Chemicals A.G.**

Dr. Ross, who will be headquartered in Zug, Switzerland, previously served as supervisor of organic research at Metal and Thermit's research centre in Rahway, N.J. In his new position he will be responsible for supplying the technical assistance that is required by M. and T. Chemicals A.G. in its contacts with European companies under license to produce M. and T. inorganic and organo-metallic chemicals, organic coatings and electroplating chemicals.

* * *

Mr. G. J. Hopper has joined **D. A. Stuart Oil Co. (G.B.) Ltd.** as applications manager. In this position he will be primarily concerned with the sale, to manufacturers and blenders, of cutting oil bases compounded at Wolverhampton by D. A. Stuart Oil Co. (G.B.) Ltd., which is a wholly owned Amber subsidiary.

Mr. D. A. Whyatt has been appointed group marketing manager of the **Amber Group of Companies.** Besides taking overall responsibility for all aspects of marketing, Mr. Whyatt will continue as manager of the Pressurised Dispenser Division of Amber Oils Ltd.

Five appointments have been made to the board of **Blundell, Spence and Co. Ltd.** They are :

Mr. F. R. Eden, who, since 1957, has been in charge of the Industrial Division's works at Slough. Since his appointment he has been transferred to the Decorative Division.

Mr. W. H. Hulme, M.I.Ex., formerly export sales manager. He is now based on head office as an executive director.

Mr. C. C. Mell, M.I.Chem.E. Eighteen months ago he was made a divisional director and since his new appointment is responsible for the Hull works.

Mr. K. T. Saxton who is located at the Slough works and will have overall responsibility for the Industrial Division.

Mr. A. L. Smith for the past few years has specialized in promoting transport finishes to a wide variety of users, including the British Transport Commission, 'bus operators and haulage fleet operators. His appointment to the board emphasises the importance attached to this growing section of the company's activities.

* * *

Vokes Group Ltd. announce the appointment of Mr. F. V. Smith as director and general manager of their Scottish subsidiary company, **Robert Kellie and Son Ltd.,** Dundee.

Mr. Smith, has been twenty-one years with Vokes Ltd., the last fifteen as production and purchasing controller.

* * *

Mr. Keith Newham has recently been appointed industrial sales representative for the South Wales area by **Jenson and Nicholson Ltd.,** of Stratford, London, E.15.

Mr. Newham will be based in Cardiff, where the company have a depot and office, and will be assisted by Mr. Peter Rowe, technical service representative for the area.

New Patterns in Stelvetite

STELVETITE plastic-coated sheet steel produced by John Summers and Sons Ltd. of Shotton, near Chester, is now available in an unlimited range of patterns and colours.

This latest development is made possible by a new arrangement, which means that all the patterns held by the Calico Printers' Association Ltd.—the largest single collection in the world—will be available in Stelvetite.

In addition, manufacturers will be able to specify their own exclusive patterns.

This innovation is added to the Stelvetite range of standard colours and embossings.

METAL FINISHING FROM A TO Z

NICKEL PLATING - FOUR A & W ADVANCES

WHATEVER YOUR NICKEL PLATING PROBLEMS—A & W HAVE AN ANSWER THAT'S RIGHT FOR YOU!

PLUSBRITE NICKEL plating bath. Combines the seven major requirements for effective bright nickel deposits.

☐ Low costs ☐ Fully bright deposits of excellent colour ☐ Excellent levelling properties ☐ High ductility ☐ Good receptivity to chromium plating ☐ Rapid plating ☐ Easy control

SBSF—for semi-bright nickel plating at high speed, a stable, sulphur-free addition agent which gives the bath very good levelling characteristics. This semi-bright deposit is intended for use with Plusbrite nickel and is part of an excellent duplex system.

It is also useful as a fast-plating, semi-bright solution.

PLUSBRITE DUPLEX—is for use where excellent corrosion resistance and maximum ductility is required with a fully bright finish.

The addition agents do not produce harmful breakdown products and are not removed by continuous filtration through carbon.

NICKEL SULPHAMATE—provides a bath for rapid plating of heavy nickel deposits, with superior ductility and low internal stress. It is used in the production of gramophone record stampers, in electroforming, in the re-sizing of worn parts and in facing of stereos and electrotypes.

TURN PAGE FOR IMPORTANT NEWS ABOUT COPPER PLATING

METAL FINISHING FROM A TO Z

COPPER PLATING - OUTSTANDING NEW PROCESS DEVELOPED BY A&W

PYROBRITE BATH WITH PY-61C MAKES FINISHING UNNECESSARY!

The new PYROBRITE bath with addition agent PY-61C was developed by Albright & Wilson's own chemists. It is a significant advance over all previous copper-plating methods, and has been proved in commercial practice □ Albright & Wilson's PYROBRITE bath, based on pyrophosphates, is less toxic than conventional cyanide baths and much higher plating rates are possible. It has outstandingly good levelling characteristics, is easy to control and produces fully bright, close-grained, smooth deposits which will not fingermark or spot out □ The PYROBRITE copper bath is used for decorative plating, particularly as an undercoat on steel and zinc alloy diecastings before nickel and chromium plating, and for electroforming.

SILVER AND TIN PLATING - A & W LEAD THE FIELD

FOR SILVER PLATING—Plusbrite Silver addition agents give first class results for: ☐ Plating of electrical and electronic components. The deposit is unalloyed, retaining its full electrical conductivity ☐ Plating of decorative silver, tableware, cutlery, jewellery and musical instruments ☐ Plating engine bearings where minimum lubrication is available.

The Plusbrite silver plating bath provides: ☐ A fully bright deposit over an extremely wide current density range ☐ The possibility of very high plating rates ☐ A hard (110 V.P.N.) and tarnish resistant deposit ☐ Elimination of finishing in many cases.

FOR TIN PLATING—Albright & Wilson are now able to offer potassium stannate at an economical price. The potassium bath has the following advantages over the conventional sodium bath:

FOR ELECTROTINNING ☐ Higher plating speeds ☐ Less sludge ☐ Further improvements by using "High Speed" tin anodes.

FOR IMMERSION DEPOSITION ☐ Reduced sludge formation ☐ In the Phostin process for aluminium the solution composition is modified to provide a self-regulating bath requiring infrequent discarding.

NEWS ABOUT PLANT FOR PLATING AND POLISHING OVERLEAF

ALBRIGHT & WILSON SUPPLY AUTOMATIC & MANUAL PLANT

Albright & Wilson design and supply automatic as well as manual plant for electroplating and chemical polishing. The resources of Albright & Wilson make it possible to meet specific as well as general orders for process and plant. Albright & Wilson have built the first automatic plant to be installed in the U.K. for the chemical polishing and anodizing of aluminium.

PREPARATION PROBLEMS SOLVED! Albright & Wilson offer these solutions: ☐ PHOSBRITE 183 chemical polishing solution effectively and quickly provides the essential level surface on brass before bright nickel plating, even with the most intricately shaped pressings. ☐ PHOSBRITE 184 similarly acts as a chemical polishing pre-treatment before bright silver plating on nickel silver or beryllium copper. ☐ PYROBRITE—the new copper-plating bath—provides a bright level deposit, eliminating copper finishing on zinc alloy diecastings and steel pressings before bright nickel and chromium plating.

OTHER PRODUCTS Special formulations for cleaners have been devised and are available for use with A & W metal finishing processes. Special grades of activated carbon and filter aid are available for use in the purification of plating solutions.

WHATEVER THE PROBLEM plating, polishing or plant consult ALBRIGHT & WILSON

ALBRIGHT & WILSON (Mfg) LTD Metal Finishing Dept. 1 Knightsbridge Green, London S.W.1 Tel: KENsington 3422

TECHNICAL BOOKSHELF

Elementary Science for Electroplating Students and Foremen, by E. A. Ollard. (Robert Draper Ltd.). 99 pp. 18s. net.

" It is the purpose of this book to explain the elementary principles of chemistry, electricity and electrochemistry, the terms used in describing chemical reactions and the like, and the methods of calculation used in the control of electroplating operations." This quotation from the preface indicates the field the author aims to cover on behalf of students and foremen in the electroplating industry, it being assumed that their previous knowledge is limited.

No ninety-nine page book can do this satisfactorily, but it is made plain that the work is intended primarily to introduce the subjects and supplement the ideas given in standard textbooks and at specialized courses.

The general plan of the book is good ; the print clear ; the layout attractive, and clearly paragraphed. There are seven chapters : Principles of Chemistry ; Principles of Chemical Analysis ; Principles of Electricity ; Principles of Electrochemistry ; Properties of Electrodeposits ; Units of Heat and Plating Calculations. It is well indexed and has useful appendices on units, conversion factors, common substances, and strengths of commonly used acids.

The last four chapters should prove very useful to the practical plater, but the earlier chapters on the Principles of Chemistry and Principles of Electricity contain far too many errors, are carelessly written, and need thorough revision before they can be considered adequate. For example, we read that a coulomb is a measure of the total current used ; that a watt is a unit of electrical energy ; that the number of watts being consumed is the volts multiplied by the amps. Also, if hydrochloric acid and sodium chloride are mixed together, sodium chloride and water are formed. Again that a certain chemical equation tells us exactly the composition of the substances with which we are dealing, and exactly what happens when we mix them together. That hydrochloric acid is a compound of hydrogen and chlorine, that water consists of two atoms of hydrogen combined with one of oxygen, that a normal solution contains an equivalent weight of a substance in grams dissolved in one litre of water, and that hydrogen is H, are further errors.

Yet another weakness is the use of ' loose ' terms such as " amount " of current for " magnitude " of current—twice as " much " gas for twice " the volume " of gas—" mixed with " for " reacts with "—" substance for " element or compound."

It is further noted that the " old fashioned " explanation for the electrolysis of copper sulphate solution is given. The student is led to believe that the well known experiment on electrolysis of acidulated water shows that water is actually composed of two atoms of hydrogen and one of oxygen. The function of an ammeter shunt is omitted and a wrong explanation of its mode of operation given. Poor English clouds the explanation of the working of the dynamo, which requires a diagram to assist the text. The explanation of the circuit arrangement for electroplating is very clumsily expressed, and by virtue of defective sentence construction the student could gain the impression that plating solutions simply consist of a coil of wire inside a protective casing !

Such inaccuracy is thoroughly to be deplored in a textbook intended to introduce a subject.

The overall general impression obtained is that the idea which led to the writing of the book is praiseworthy, but the writing, in parts, has been hurried and careless, without revision, and with little thought about the limitations of the student, whom, in many ways, it would mislead rather than guide.

C. R. DONCASTER.

The Author comments on the above review as follows :

" I would agree with many of the reviewer's comments, but must emphasize that the book was written with the idea of instilling into plating-shop operatives, with little or no knowledge of chemistry, a basic understanding of the processes with which they are working. With this in mind it was felt desirable to over-simplify much of the theory involved rather than to use exact terminology that would have little chance of being understood by those for whom the book primarily was written.

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The book is clearly printed, attractively bound and contains a number of illustrations.

Potential readers of this book may be divided into two classes, the first those that were present at the meeting and the second, by far the larger class, those who were not.

For those who were present the book contains a useful record. At a meeting of this type it is not always possible to remember all the points that were raised in the papers and it is therefore extremely interesting for anyone who was present to look again over both papers and discussion, as these were not published in extenso by the I.M.F.

For those who were not present, the book provides an extremely useful account of the present position of nickel-chromium plating. It should undoubtedly be read by everyone who is working in this field and there is little doubt that for quite a few years to come it will provide extremely useful information for the plating-shop personnel. The publishers are undoubtedly to be congratulated on producing this book and one feels that it will be a most useful volume on the shelves of any plating shop or plating laboratory.

E. A. OLLARD.

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METAL FINISHING FROM A TO Z

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P.J.A. INTERNATIONAL TECHNICAL CONFERENCE

THE illustration shows a group of chemists, chemical engineers and technologists from many European countries and from all parts of the U.K., who met at the Pinchin, Johnson and Associates Technical Conference held in October. The conference, opened by the Chairman, Sir Alan Wilson, F.R.S., took place at Coventry in the Courtaulds' Acetate and Synthetic Fibres Laboratory. Twenty-six papers were presented and subsequent discussions ranged widely over the subject of paint research and development.

NEW COMPANIES

" Ltd " is understood, also " Private Co." Figures = Capital, Names = Directors, all unless otherwise indicated.

Lamp Metals, Magnet House, Kingsway, W.C.2. October 19. £750,000. To acquire part of the undertakings of A.E.I. Lamp and Lighting Co. Ltd. and of The General Electric Co. Ltd ; to carry on business of manufacturers of and dealers in metal and metal alloys and articles made therefrom, etc. Directors not named.

Cadplate, Rhigos Road, Treherbert, Glam. October 23. £100. To carry on business of electroplaters etc. Nestor H. Greenslade, Brian Roberts.

E. Jones (Feltham). 1 Rowland Avenue, Kenton, Harrow, Middx. October 23. £100. To carry on business of electroplaters, etc. David C. Brodie.

Alfred Sargent (Polishers), 405 Farm Street, Hockley, Birmingham, 19. November 2. £5,000. To carry on business of polishers, chromium and electroplaters, etc. Alfred T. Sargent, Ada E. Sargent.

Deansfield Plating Co., Colliery Road, Wolverhampton. November 3. £500. Alfred Clifford, Reuben Clifford.

Rapide Polishing Co., 22 Bloomsbury Square, W.C.1. November 7. £100. To carry on business of metal polishers, etc. Frederick R. Jones, Edward V. Cooper.

From the Register compiled by Jordan & Sons Ltd. 16 Chancery Lane, London, W.C2.

Distributor's Conference

A VERY successful three-day conference recently took place in Weybridge, Surrey. It was organized by Electro-Chemical Engineering Co. Ltd., of Woking, Surrey (a subsidiary of EFCO Ltd.), and was attended by 28 representatives of the EFCO-UDYLITE organization in Europe. Also present were Mr. L. K. Lindahl, chairman of the board of The Udylite Corporation, Detroit, Dr. Henry Brown, director of research of The Udylite Research Corporation and Mr. J. Barton, chief engineer of Frederic B. Stevens, Inc., U.S.A.

Important developments in new processes and equipment were discussed, including the new Satylite process which will shortly be launched throughout Europe. This plating process produces an attractive satin finish direct from a nickel bath.

Mr. Lindahl took the opportunity of announcing that a merger had been agreed between the boards of Metal and Thermit Corporation and The Udylite Corporation, Detroit. Metal and Thermit are well-known throughout Europe for their Unichrome range of processes and The Udylite Corporation is the largest electroplating supplier in the world. It is understood that the merger is subject to the approval of the Stockholders of each corporation.

Social events during the conference included a cocktail party given by Mr. A. Smart, managing director of Electro-Chemical Engineering Co. Ltd., and Mrs. Smart, and a dinner at the House of Commons sponsored by Mr. J. Page, M.P., for Harrow West.

FORTHCOMING MEETINGS

January 2

Institute of Metal Finishing (Midland Branch). Discussion on " Stripping and Reclamation of Defective Plated Work " opened by T. E. Such, at the James Watt Memorial Institute, Great Charles Street, Birmingham 3. 6.30 p.m.

January 9

Institute of Metal Finishing (South-West Branch). " American Developments in Plating Zinc-base Die Castings " by L. A. J. Lodder, at the Royal Hotel, Bristol. 7.30 p.m.

January 10

Institute of Metal Finishing (Organic Finishing Group). " Performance and Economics of Water-Thinned Industrial Finishes," by J. R. Berry, at the British Institute of Management, Management House, 80, Fetter Lane, E.C.4. 6.30 p.m.

January 15

Institute of Metal Finishing (London Branch). " Industrial Applications of Electro-polishing of Stainless Steel " by P. A. Charlesworth, at the Borough Polytechnic, Borough Road, London, S.E.1.

January 16

Institute of Metal Finishing (South-West Branch). " Instruments for Measurement of Coating Thickness," by E. Laker, at the Royal Hotel, Bristol. (Joint meeting with the Institution of Inspection Engineers). 7.30 p.m.

January 17

Institute of Vitreous Enamellers (Southern Section). " Simple Chemistry of Mill Additions and their Purposes " by Dr. P. W. Ranby, at the Constitutional Club, Northumberland Avenue, London, W.C.2. 7.15 p.m.

January 19

Institute of Metal Finishing (Sheffield and N.E. Branch). " Plating Jigs." Joint meeting with the North-West Branch at the Engineers Club, Manchester. 7.30 p.m.

Institute of Metal Finishing (North-West Branch). " Rack Design " by F. Essex at the Engineers' Club, Albert Square, Manchester. 7.30 p.m. (Joint meeting with Sheffield Branch).

Society of Chemical Industry (Corrosion Group). " The Corrosion Behaviour of Decorative Nickel Chromium Coatings " by G. N. Flint, at 14 Belgrave Square, London, S.W.1. 6.0 p.m.

Trade and Technical Publications

A major article a recent issue of the Canning Journal, published by W. Canning and Co. Ltd., Birmingham, is entitled "Plating Shop Layout and Installation." Extracts from two lectures given by members of the company's staff illustrate further aspects of the Canning advisory service; a further article discusses the problems of plating-shop effluent treatment.

* * *

The whole of "John Summers Review" No. 5, published by John Summers and Sons Ltd., Shotton, Chester, is devoted to their plastic-coated sheet "Stelvetite" and its uses. In particular, the use of this material for shelving etc. in self-service stores is featured.

* * *

Inco-Mond Magazine (No. 18) contains two articles of interest to electroplaters. The first deals with the automatic plating of "Supataps" at the works of F. H. Bourner & Co. (Engineering) Ltd., Crawley. All "Supataps" and Spa taps and mixers are plated to B.S. 1224/1959/ Ni_3C and carry the blue label of the Mond Labelling Scheme to show that they are suitable for long service in the steamy conditions of kitchens and bathrooms. The plant used is a Canning "Trojan" automatic with an output of 520 sq. ft. of plating per hour. The plant incorporates hot and cold cleaning cycles, an acid dip, copper plating (cyanide), Efco-Udylite bright nickel, followed by chromium plating.

The second article deals with the rhodium plating of silverware. The B.J.S. Electro-Plating Co. Ltd., London, N.W.6., has recently developed a special finish called "Rhodoplate" which is particularly suitable for silverware. Silver articles plated by this process can be given everyday use, needing only an occasional wash. Should a repair be needed to the base structure, Rhodoplate can be removed electrolytically without causing damage and the article can be replated after repair.

Inco-Mond Magazine is published by The International Nickel Co. (Mond) Ltd., Thames House, Millbank, London, S.W.1.

* * *

Hanson-Van Winkle-Munning Co., offer a new bulletin, Co-105, describing and illustrating a full line of both liquid and bar compounds for automatic and manual buffing and polishing operations.

This bulletin is of value to both the novice and experienced operator. General recommendation charts for both bar and liquid compounds have been carefully compiled and will be helpful to compound users. Principal classifications of buffing and polishing compounds and their applications are described in detail.

In addition to describing buffing and polishing compounds for all types of metals, the bulletin discusses compounds for finishing hard rubber and plastic products.

Bulletin available from Hanson-Van Winkle-Munning, Co. Matawan, New Jersey U.S.A.

* * *

A new 8-page brochure from the Shandon Scientific Co. Ltd., 6, Cromwell Place, London, S.W.7. describes a wide range of apparatus for the metallurgical laboratory, available from the company and manufactured by Buehler Ltd., U.S.A. The range includes such apparatus as cutters for metallurgical specimens, grinders, mounting presses, polishing wheels, electropolishing equipment, ultrasonic cleaning equipment, etc.

* * *

"Precision Control in Electrical Feeding" is the title of Technical Publication No. S/109 from Wallace and Tiernan Ltd., Power Road, London, W.4. Included in the wide range of equipment described are such items as chlorinators, reagent feeders, flow recorders, automatic feeders for dry chemicals, cylinder or drum changeover devices, etc. etc.

* * *

A new 16-page leaflet (List 70/1) issued by the Cambridge Instrument Co. Ltd., 13 Grosvenor Place, London, S.W.1., describes their range of hygroscopic and wet and dry bulb humidity indicators, recorders, and controllers. The leaflet begins with an introduction to the measurement of relative humidity and its importance in industry, and describes and illustrates the two common methods of measurement.

The instruments described include a hygroscopic indicator for measuring the moisture content of paper and similar materials, mechanical and electrical wet and dry bulb recorders, combined temperature and humidity recorders and various types of controllers including a multi-point electronic recorder/controller.

The publication also provides general information on several humidity control systems and contains a short bibliography relating to other sources of information on the measurement and control of humidity.

* * *

A new book, "Survey of a Chemical Group," has been published by Albright and Wilson Ltd., 1, Knightsbridge Green, London, S.W.1. The Albright and Wilson Group comprises over thirty companies with manufacturing units in eight countries. The book is an attempt to give an account of the character and work of the Group at a specific point in time—mid 1961—rather than to trace its history or speculate upon its future development.

Albright and Wilson's operations have always hinged upon the manufacture of phosphorus and its compounds. They still do, but since the war a number of important new applications for phosphorus chemicals have been developed which have altered and greatly enlarged the scope of the company's work. At the same time, further changes in the character of the Group's activities have developed through its entry into new fields of chemical manufacture — silicones, sulphuric acid, cement, agricultural chemicals, pharmaceutical chemicals, surface-active agents, essential oils, perfumery chemicals, flavours and essences for foodstuffs, and chemicals used in the treatment of textiles and metal surfaces. Taken together, these changes have substantially increased the areas in which Group products impinge upon industry and the ultimate consumer.

The book lists the member companies of the Group, refers to technical and commercial resources, lists the main products of the Group and incorporates some historical notes. This book is excellently produced and is illustrated with many colour photographs.

* * *

An I.C.I. paint system incorporating Flamboyant enamel, or stoving enamel and stoving varnish is being used on the mopeds and cycles produced at the Partizan Cycle Factory, Subotica, Yugoslavia. This is one of the items of interest in a recent issue (No. 18) of "Finishing Facts," published by I.C.I. Ltd. (Paints Division), Slough, Bucks. Additional articles deal with the company's new five-storey research building, fluorescent paints for aircraft, and finishes for the road-making equipment of Euclid (Great Britain) Ltd.

(*Continued in page* 472)

Trade and Technical Publications

(*Continued from page* 471)

" A Complete Vitreous-Enamelling Service " is the title of a brochure published by Metal Porcelains Ltd., Cornwall Road, Smethwick, Staffs. The company can supply frits, fusing furnaces, drying ovens, pickling plant, spray booths, mill-room equipment, perrits, colouring oxides, flocculating agents, etc. and the company's chemists and technicians will assist and advise customers in overcoming enamelling difficulties.

* * *

A fully descriptive colour folder has just been published by Tool Treatments (Chemicals) Ltd., Colliery Road, Birmingham Road, West Bromwich, Staffs proprietors of " Black Knight " metal-finishing treatments, dealing with the new bright-protective metal process " Luster-on 70." This is a simple 20 seconds, fumeless, chemical dip process for copper, brass and bronze products. By passivating the surface, it is said to provide resistance to corrosion, staining and tarnishing and a high degree of lustre. The new process can be used as a final finish or as a pretreatment prior to plating, and as it is non-fuming, no ventilating equipment is needed.

" Luster-on 70 " is a product of The Chemical Corporation, U.S.A. and is licensed to Tool Treatments (Chemicals) Limited, for use in Great Britain.

* * *

Sales information bulletin No. 9, published by The Pyrene Co. Ltd., Metal Finishing Division, Great West Road, Brentford, Middlesex, deals with "Spray-Gun Bonderizing." This process is intended for use on good quality sheet steel and its applications cover specialist production, small-scale production of components too large or too awkwardly shaped to be treated in orthodox "Bonderizing" plants, and production circumstances where the installation of orthodox plant is impractical or unjustified, *e.g.*, through lack of space, or services, small production runs, non-standard production.

The nature of the " Bonderite " coating produced by " Spray-Gun Bonderising " is said to be entirely comparable, as regards corrosion resisting and paint bonding qualities, with those produced by the orthodox methods.

* * *

John S. Craig and Co., Ltd., have published a revised edition of their " Manual of Marine Paints," the authoritative reference book and practical guide to the protection of metals.

When first published in 1959 the Manual was designed for the marine field, but its chapters on the problems of meeting corrosion, on the treatment of shot-blasted steel, the protection of aluminium and galvanized iron, and other specialized products such as fire-retarding plants and coatings for the protection of refrigerated areas, have found wide application in constructional engineering and in manufacturing industries generally.

The 52-page, two-section Manual is completely comprehensive in scope. Section A defines in detail the various requirements in the protection of metals. Section B recommends service-proved formulations to meet these requirements, with the emphasis on products for effective use under normal rather than ideal painting conditions. The cost factors of time and labour as well as of products, are given realistic consideration when recommending coatings—a factor of increasing importance in competitive industry.

Included in the revised edition are chapters on the new Ferrogel thick film primers for the protection of steel under difficult service conditions, full information on the treatment of shot-blasted steel—a most important development in which the Craig Company have specialized—and detailed data on protecting machinery and storage areas.

Copies of the Manual are available on request from John S. Craig & Co. Ltd., 12-40 Bogmoor Road, Glasgow, S.W.1.

* * *

At a time when the Chief Inspector of Factories report just published shows last year's total industrial accidents 190,266 — 16,195 more than the previous year — 675 ending in death—a new edition of " Safety and Health in Industry "is being made available without cost.

The seven major sections of this 150-page publication with over a hundred photographs, diagrams, charts, and other illustrations cover —1, Machine Guarding ; 2, Industrial Health Engineering ; 3, Personal Protection ; 4, Material Handling ; 5, Housekeeping and Maintenance ; 6, Fire Protection ; 7, General Section.

In a " down to earth " foreword to the publication deploring the rise in accidents, Former Deputy Chief Inspector of Factories—R. Bramley-Harker, calls for " *something more.*"

He lists—among his suggestions—Plan a Safety Campaign . . . Job Training . . . Foreman Training in Safety . . . Plan a Safety Code . . . organize a Top Hat Safety Course for the " Top Brass " . . . Tighten discipline. He concludes his foreword with the thought provoking . . . "*A positive Direct Action is required—if it is not made—no decrease in accidents will occur nor can be expected.*"

This book has been produced primarily as an easy-to-read guide on basic safety, health and welfare in industry and is particularly useful to the foreman, works manager, or executive.

Copies of the book are available free from The Industrial Health and Safety Centre—97, Horseferry Road, Westminster, London, S.W.1.

" Colour Today "

" COLOUR Today " is a 20-minute analytical, educational and entertaining film in Ektachrome with full sound. In sponsoring this film Pinchin Johnson have been aware of the need for a greater awareness of designed and functional colour on all the products which are manufactured in this country. The great need is to meet the competition from the European Common Market where colour quality and awareness of good colour is making inroads into some of our markets.

" Colour Today " has been made under the direction of colour experts. All the material is new and many of the sequences are filmed for the first time.

The film commences by showing our colour traditions in dress, pageantry and traditions, and then moves into British products as they used to be and as they are today. Nearly every car, machine or mechanical object started life in a funereal black finish. The film proceeds to question how and what we see and deals with the problems of light, colour and vision and includes colour blindness guides and " after image " effects. Problems of vision and identification are demonstrated in many ways, including a run over the M.1.

The film continues into a sequence of colour articulation. The harmonic orders, the juxtaposition of colours and the entirely new colour mixing demonstrations are startling. This section includes the Munsell Colour System and the heating of metals and pigments. Shots are included of the chemist's contribution to colour and pigments in the laboratories. From colour demonstration the film moves into the application of colour and colour design in engineering and consumer goods of both English and foreign manufacture.

The film has been produced by Cygnet Film Productions.

Latest Developments in PLANT, PROCESSES AND EQUIPMENT

New Non-Dusting Basic Pigments

AFTER eight years of development Ferro Enamels Ltd., Wombourn, Wolverhampton, have produced an entirely new range of non-dusting basic pigments.

Many outstanding properties are claimed for the new pigments, the most important of which are stability in heat and light fastness to temperatures in excess of 300° C. In addition, they are non-bleeding and migrating and give good tintorial power, as well as clean and bright colour shades ; combined with the properties of non-dusting, minimum contamination and minimum purging time, the Ferro pigments will considerably reduce handling problems.

Further, the colours are compatible and can be blended with one another, thus providing a variety of colour shades with the smallest colour range.

The new pigments are also suitable for all grades of polystyrene, polyethylene, nylon, polypropylene, cellulose acetate, phenolics, ureas, polyester and epoxy resins and P.V.C. (with the exception of Brown FW 1134 and 1135 and Black FW 1731) and are low in cost.

Plasma Flame Spray Gun

PLASMA now makes it possible to deposit as a coating many types of metals, refractories and oxides previously denied research and design engineers. Materials that can be sprayed include chromium, cobalt, molybdenum, tungsten, chromium carbide, tungsten carbide, rare earth oxides, titanium oxide, calcium zirconate and in fact most materials that do not decompose when melted. These materials, applied with the METCO Type MB plasma flame spray equipment, are claimed to give a dense coating and a high degree of bond to the base metal. The equipment has been designed for development work in the jet and rocket motor fields, missile work, nuclear and electronic industries and research work into applications involving the use of these high temperature materials. Further details from METCO Ltd., Chobham, Woking, Surrey.

Bench Rectifier Line

A NEW bench rectifier line (Fig. 1) manufactured by Hanson-Van Winkle-Munning Cy., Church Street, Matawan, N.J., is designed to provide maximum power in a minimum space. The rectifiers' one-piece cabinet shell comes off easily, making all internal parts easily accessable. The unit has only 5 parts, making the line both economical and easy to maintain. The rectifiers are applicable to laboratory use, small plating installations and specialized battery charging.

The ratings of the units range from 150 amp at 24 volts, down to 25 amp at 6 volts. There are 3 basic cabinet sizes with a standard face size, 13 in. x 15 in. Depths are 10 in., 15 in., and 20 in.

All units are equipped with large scale ammeter and voltmeter for quick meter readings. A powerstat provides vernier control of voltage from zero to rated voltage.

Fig. 1.—Bench rectifier line

Fully Automatic Spraying and Stoving Machine

AUTOMATIC Equipment Ltd., of Daleside Road, Nottingham, have developed a fully automatic spraying and stoving machine (Fig. 2).

It is designed for fast and economical paint finishing of such items as toys and fancy goods, shoe heels, hardware, electrical instruments, motor-car accessories and similar components. This compact unit is designed to provide a high work output from limited floor space, is totally enclosed to prevent dust settling on newly painted work, and is easily operated by unskilled labour.

Controlled paint application is ensured, with minimum paint overspray waste and consistent process time for flash-off of solvents, stoving and cooling. This reduces to a minimum the percentage scrap due to variable human element control, and mishandling of wet painted work which can result in substantial savings in running costs. A metal pre-treatment station to enable complete process without handling is available.

There is mechanical traverse with a full range of stroke adjustment, and one or more traverses can be fitted to a unit with a complete series of motions, including vertical, horizontal, arc spraying and internal coating.

Any form of stoving can be incorporated, including infra-red, forced-draught or a combination of both, using gas, electricity, oil or steam as the heating medium. In addition, the paint extract system has filtered air inlet and combines the best in water curtain rear sheet with efficient scrubbing by water jets.

The unit is completely flexible and can be designed to spray and stove at a pre-determined output rate, with the work set at 3-in. pitches or multiples of 3-in. pitches. A special feature of the design allows the fitting of a selective spray device to prevent spraying on unloaded work carriers.

All units are custom built and moulded to suit individual shop layouts, outputs and process times, and if required, can be supplied in flameproof form for handling materials of all classes.

Chromate Conversion Treatment

A RECENT addition to the Cromcote range of processes, is a chromate conversion treatment for brass and other cuprous alloy surfaces. The treatment is claimed to be valuable in preventing tarnishing of the surface and rendering it resistant to finger-marking and other similar damage. The process is known as Cromcote B.R.

The bath is made up by diluting 1 part of Cromcote B.R. concentrate with 25 parts of water. The performance of the bath may be improved by the addition of 1 ml. of a 1 per cent. solution of wetting agent per litre of bath solution (5 ml. per gal.). The parts to be processed, which should be free of grease, are immersed in the treatment bath for 1 to 3 minutes at room temperature. They are then removed, rinsed thoroughly and dried at not more than 90°C. Chemical consumption in operation of the process is approximately $\frac{3}{4}$ gm. per sq. ft. of surface treated.

The bath is controlled by a straightforward titration. To 5 ml. of the bath solution are added 10 ml. of 5N sulphuric acid and 40 ml. of distilled water. This is then titrated with No. 3 Testing

(*Continued in page* 476)

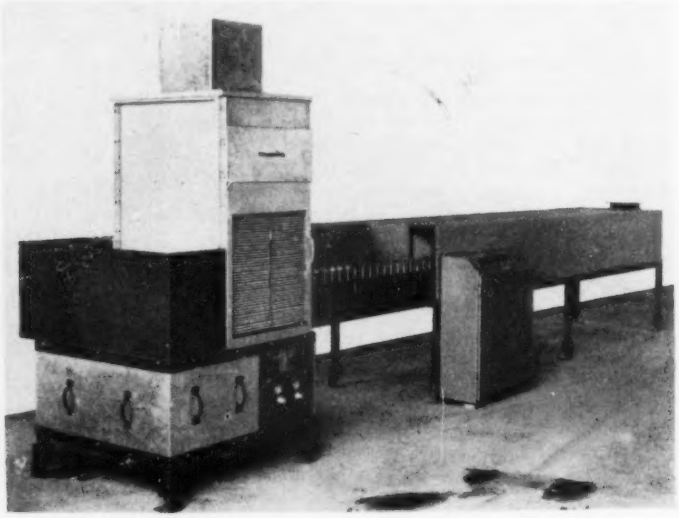
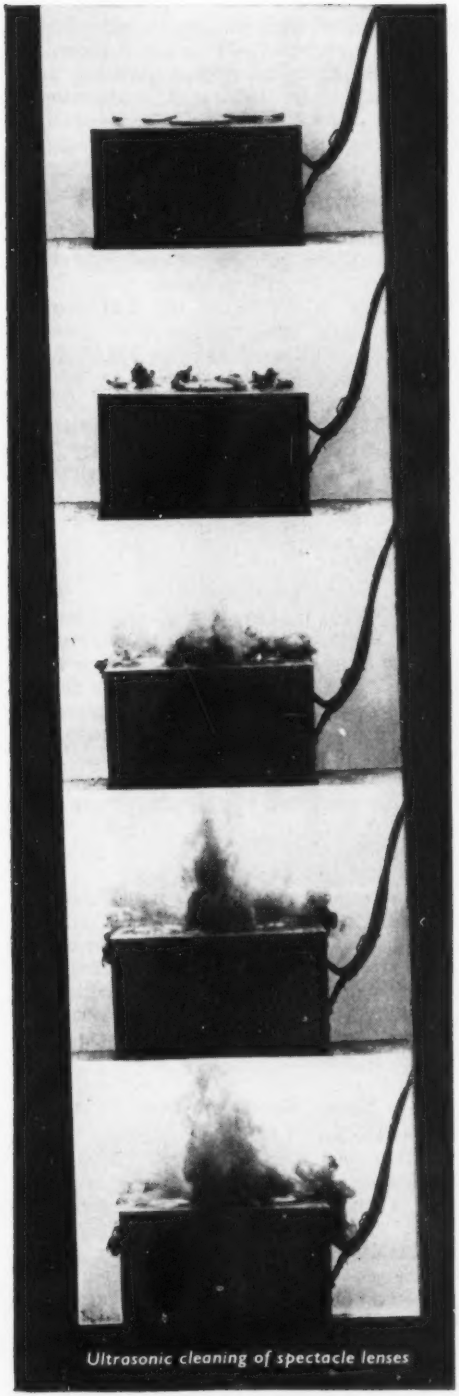


Fig. 2.—Automatic spraying and stoving machines.



Ultrasonic cleaning of spectacle lenses

Ultrasonic Cleaning

cleans ultra-efficiently

HOW?

By introducing high frequency pressure waves in liquid cleaning media (alkaline or solvents), causing momentary tiny vacua, called cavitations. The effect is a mechanical scrubbing action on surfaces to be cleaned, removing all oily or solid contaminations like dirt, swarf or grease. The pressure waves are created by immersed nickel transducers, which oscillate at a frequency of 22 kilocycles, the source of which is a valve generator converting the mains current to high frequency current.

WHAT?

Ultrasonic cleaning is the most effective method of cleaning articles which are difficult to clean by ordinary methods. In particular, parts which are contaminated with solid soil, such as pieces of polishing cloth or polishing paste, swarf in fine holes, enclosed angles, ridges, ledges, hollows; parts with dirt deposits of long standing; parts having residues of hardening compound, etc.

WHERE?

Ultrasonic cleaning can be applied in any kind of conventional cleaning installation, such as alkaline cleaning tanks, Tri-degreasers, etc., by simply immersing the nickel transducers in the cleaning liquid. Special equipment entirely adapted to particular applications of Ultrasonic cleaning, either hand operated or fully automatic, can be supplied.

FURTHER QUESTIONS . . . concerning Ultrasonic Cleaning, its capabilities and characteristics, are answered in our special leaflet. Please write for a copy.

From Roto-Finish come these other surface treatments:

Barrelling and Vibrafinishing for metal and plastics to deburr, descale, deflash, radius, surface blend, polish or lustre.	Electropolishing.
	Ultrasonic cleaning.
	Mechanical cleaning.
	Grisiron Alkaline cleaners.
	Euron cleaner passivator.
Atram phosphating processes.	Conversion and protective coatings.

Tell you more about any or all of them? We would be happy to if you write or telephone us.

Rely on

Roto-Finish

to provide the finishing touch

Mark Road, Hemel Hempstead, Herts.
Boxmoor 4600 (PBX)

For Holland:
N.V. Roto-Finish Mij., Rotterdamseweg 370A, Delft, Holland

Solution using No. 4 Indicator. The testing solution is run in from a burette until the colour changes from reddish brown to green. This should take 20 ml. The bath is replenished by addition of the B.R. concentrate at a rate of 1.8 ml. per litre per point below normal strength (8 ml. per gal.).

Two processes for zinc and galvanized steel surfaces have also been developed.

Cromcote Z.C. is the process which would normally be offered as a corrosion protection and paint-bonding treatment. The Z.C. chemical as supplied, is diluted with 25 parts of water to make the operational strength. Performance of the solution may be improved by the addition to the bath, after make-up, of 1 ml. of a 1 per cent. solution of wetting agent to every litre of bath solution (5 mls. to each gallon). The work to be processed should be free of grease and corrosion products. These last can be removed by a short immersion in a 1 per cent. nitric acid solution at room temperature. The treatment time is normally of 1 min. duration at room temperature. This produces a colourless film having high corrosion resistance with good paint-bonding properties. A golden-coloured film may be produced by increasing the immersion time to 3 min. Laboratory tests have shown however that the paint adhesion properties of this coloured film are considerably inferior to those of the colourless film. After processing, the work should be thoroughly rinsed and dried, at not more than 90°C.

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Cromcote Z.H. is a special development of the Z.C. process designed for the treatment of newly-galvanized work. The steel which has been galvanized may be quenched direct into the Z.H. bath, thereby enabling the treatment to be carried out in the production line with the minimum of interference with throughput. Cromcote Z.H. should not be offered or used for any other application. The process comprises a make-up and a replenishment concentrate.

The make-up concentrate, Cromcote Z.H.1 solution, is diluted with 10 parts of water and 1 ml. of a 1 per cent. solution of wetting agent is added per litre of bath solution (5 ml. per gal.). The bath is heated to 70-75°C. and is then ready for use. The galvanized work is quenched direct from the galvanizing bath at a temperature of about 200°C., into the Z.H. bath. An immersion time of 1 minute is sufficient. After removal from the bath the work should be rinsed thoroughly and dried at not more than 90°C. The process will give a colourless film which considerably increases the corrosion resistance of the galvanized layer and offers excellent resistance against the formation of " white rust " on the zinc surfaces.

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Further details from The Walterisation Co. Ltd., Purley Way, Croydon.

Pressurized Container

SOLUS-SCHALL, County Building, Honeypot Lane, Stanmore, Middlesex are marketing a new type of pressurised container, the Flexi-spray, to spray their Spotcheck penetrants, Zyglo fluorescent penetrants, magnetic inks and associated materials on to specimens for the detection of cracks, flaws and other defects.

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GRISIRON G.42 is claimed to have proved particularly successful in de-naturing the most difficult wood finishing materials such as polyesters, which hitherto had been quite a considerable problem. Used at a 2 per cent. concentration, this additive is very economical.

(*Continued in page* 478)

Improved Corrosion Resistance for Zinc with the NEW BONDERITE 250 SERIES

The 'Bonderite' 250 Series of chromating processes have recently been developed for the protection of zinc surfaces such as hot dip galvanised steel, electrogalvanised steel and zinc alloys.

Formulated with large scale production requirements in mind, these processes are economical to operate, simple to control, and are backed by the unrivalled Pyrene technical service.

Applied cold by immersion or spray, 'Bonderite' 250 processes are available for producing both colourless and yellow films. The resultant coatings are corrosion resistant in their own right and also provide an excellent base for subsequent painting.

THE Pyrene TRADE MARK COMPANY LIMITED

METAL FINISHING DIVISION

GREAT WEST ROAD · BRENTFORD · MIDDLESEX · Tel: ISLeworth 4131

Solution using No. 4 Indicator. The testing solution is run in from a burette until the colour changes from reddish brown to green. This should take 20 ml. The bath is replenished by addition of the B.R. concentrate at a rate of 1.8 ml. per litre per point below normal strength (8 ml. per gal.).

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(*Continued in page* 478)

Improved Corrosion Resistance for Zinc

IRREGULAR

PAGINATION

Metal Cleaning Products

THE Metal Industries Division of Diversey (U.K.) Ltd., of 42/46 Weymouth Street, W.1., announces three important additions to its existing range of metal cleaning products.

Diversey No. 1107 is a modern electrocleaner specially formulated to eliminate smut problems. It is claimed that the product has a powerful cleaning action, especially where difficult types of soil are encountered. Diversey No. 1107 is a granular, free-flowing material, non-dusting and non-caking. Readily soluble in warm water, it has a special blend of wetting agents which help it to penetrate and loosen contamination very rapidly ; oils and greases are emulsified. It is stated that the product gives a controlled foam blanket, preventing caustic spray and the risk of hydrogen explosions. The makers claim that the exceptionally high conductivity of these working solutions reduces power requirements and processing time. The product is recommended for use with all ferrous metals and with copper, brass and bronze. It can be used either cathodically or anodically. It is normally used at a working solution strength of 6 to 8 ozs. per gall of water (25-100 amps. per sq. ft. ; 170-200°F.).

Diverstrip G-20 is a new caustic soak-type paint stripper, suitable for use on all metals except zinc and aluminium. The makers say that this material gives extremely rapid penetration of a very wide range of paint coatings. It is stated that paint films are quickly dissolved and that the vehicles are rapidly emulsified and saponified. An important advantage claimed is that there is no re-deposition of paint films and oils on to stripped surfaces. It is also stated that the free-rinsing qualities of the product ensure complete removal from treated surfaces. Laboratory tests, using the product at a concentration of 10 ozs. per gal. (200°F.), showed that single coatings of 16 widely different types of paint were removed in 15 minutes or less. Diverstrip G-20 is recommenced for cleaning paint spray booth equipment. It is a granular, free-flowing compound, non-dusting and non-caking, and readily soluble in water. It is used in water solutions at concentrations ranging from 10 to 20 ozs. per gall of water at temperatures of from 200°F., to boiling point. An ordinary steel tank with steel heating coils may be employed.

Diversey Vitrosol is a unique heavy-duty soak cleaner for ferrous metals. It is recommended for use as a pre-soak cleaner prior to electrocleaning with Diversey No. 1107 and is also suitable for use in either soak or barrel cleaning operations prior to assembly, painting, or other surface finishing. It is recommended for use in automatic plating lines with short cycle cleaning. It is not suitable for use on aluminium or soft metals. Vitrosol is a white, granular free-flowing compound, readily soluble in cold water ; it is non-dusting and will not cake in normal storage conditions. It is normally used at a concentration of 6 to 8 oz. per gall of water (160-190°F.), immersion time depending on degree of contamination to be removed. The makers claim that Vitrosol is ideal for the removal of difficult types of soil which are not moved by the normal soak cleaner, and contains sequestering agents which have exceptional water-softening properties. Water hardness is tied up as a soluble, complex form so that it cannot precipitate. A working solution of Diversey Vitrosol also has strong peptising power which enables inert solid dirt particles to be held in suspension. The powerful cleaning action of the product is assured by its ability to penetrate contamination, which it then emulsifies and saponifies, so that oils, tallows, fats and greases are removed from surfaces in minimum time, and the free-rinsing properties of Vitrosol reduce carrying out of solution and cut down rinsing time.

Nylon Cups for Spray Gun

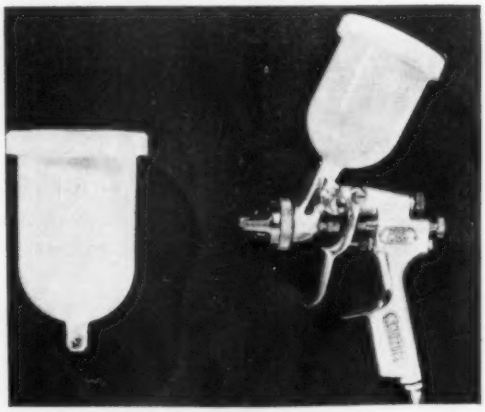
ALFRED Bullows and Sons Ltd., Long Street, Walsall, announce the introduction of two new nylon cups for use with their L600 top feed spray gun. Catalogue numbers are L81 and L82 with capacities of 2/3rd pint and 1.1/3rd pint respectively.

The nylon cups (Fig. 3) weigh only $2\frac{1}{4}$ oz. and $4\frac{1}{2}$ oz. as compared with $8\frac{1}{2}$ oz. and $14\frac{1}{4}$ oz. for metal cups of identical capacities. This substantial reduction in weight gives greater freedom of movement and considerably reduces operator fatigue.

The cups are impervious to attack by most known solvents and a further advantage is that they will not dent. Both cups have screw-on nylon lids which incorporate a special sealing device which obviates the need for lid gaskets.

(*Continued in Advert page* 29)

Fig. 3.—Nylon cups



Plant Processes and Equipment

(*Continued from page* 478)

Acrylic One-Coat Finish for Metal Products

ARMACRYL, a new acrylic one-coat finish for metal products and equipment of all types, has been introduced by Griffiths Bros. and Co. London Ltd., of Armour Works, Well Lane, Wednesfield, Staffs. It is claimed to be particularly suitable for the finishing of domestic appliances of all kinds, electric fire casings, photographic processing dishes and equipment, switch boxes, safes and equipment used in conditions of frequent condensation and high humidity, operating theatre and general medical equipment, catering and food manufacturing appliances and machinery, chemical balances, bobbins, hosiery manufacturing machinery, photo copying machines and oil burning plant.

The finish is especially valuable for application on products manufactured for export to tropical and semi-tropical climates.

The outstanding properties claimed for Armacryl are :— humidity resistance ; hardness ; resistance to colour change on heating, over stoving, or exposure to exterior weather conditions ; chemical resistance ; grease, stain, and detergent resistance ; flexibility and impact resistance ; and adhesion.

These properties are all obtainable with a one-coat application on steel, without primer, (which latter need only be used if the metal surface is poor and needs filling). The finish can also be applied directly to Zintec, but aluminium may require chemical pretreatment of the Alechrome type if the surface is highly polished.

Application can be by spraying or dipping, and stoving by convection should be for a minimum of 300 F. for 30 minutes. Performance is improved by increasing stoving—350 F. for 45 minutes.

Floor Topping

TRETOL Epiflor — the trowel applied, oil and acid resistant floor topping—is now available in two grades. The manufacturers have developed a special heavy duty grade, for use where the flooring must withstand extremely hard wear. The new grade is claimed to retain the resistance of the standard grade to oils and acids, etc., both grades being completely non-slip.

The standard colour range of Epiflor has been widened to include dark grey; this shade has proved most popular where only certain sections of a floor are to be treated. This flooring is being used in many factories, plating shops, garages, etc. where new areas can easily be laid by the maintenance staff without holding up production.

Full data can be obtained from Tretol Ltd., Tretol House, The Hyde, London, N.W.9.

RS

ELECTRO-PLATERS

A.I.D., A.R.B. & I.A. Approv

ELECTRO-PLATING—Chrome, Copper, Nickel, Cadmium, Silver, Zinc, Bright Nickel, Bronze, Tin, etc.

ANODISING—Chromic and Sulphuric Acid processes. Decorative Silver Anodising and Sealing in longest dimensions a speciality.

STOVE ENAMELLING · CELLULOSING · CHROMATING
PHOSPHATING · PASSIVATING · LACQUERING

OUR FACTORY, *equipped with a large, modern and efficient Plant, can undertake all types of Metal Finishing.*

24-HOUR SERVICE *on repetition work.*

FREE *collection and delivery.*

ROBERT STUART (LONDON) LTD.

ASCHAM STREET, KENTISH TOWN, N.W.5

Tel.: GULliver 6141 (six lines)

Classified Advertisements

SITUATIONS WANTED

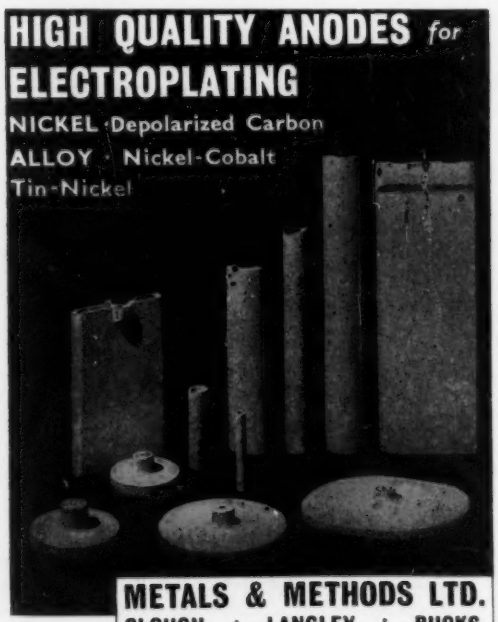
CONCIENCIOUS SKILLED PLATER (all finishes), with theory, Seeks Responsible Position. Box. No. CS.247

MACHINERY FOR SALE

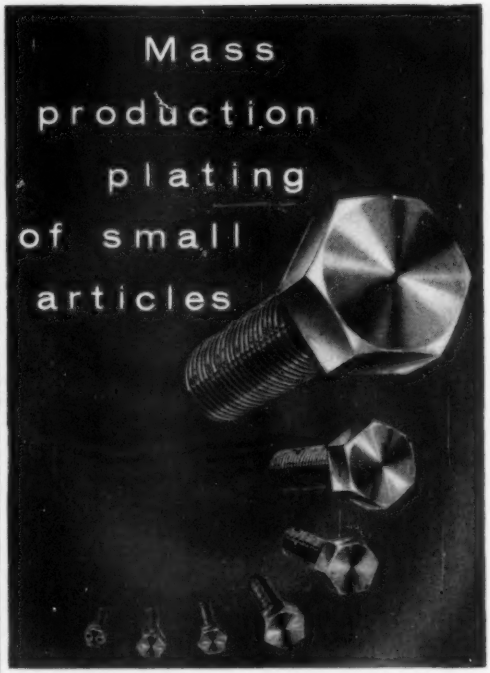
CANNINGS GENERATOR SET FOR ELECTRO-PLATING.—Comprising:-15 h.p. 3-phase 400/440V. 50c. Motor. 750 amp. 10v. Generator. 2 amp. 220v. Exciter. Mounted on one cast iron bed plate, with Switchboard. Box CG 248 M.F.J.

FOR SALE—FOUR CANNING SEMI-AUTO-MATIC NICKEL PLATING PLANTS. Capacity 90 sq. ft./hr. each. Also Two Canning return-type Auto-matic Chromium Plating Plants capacity 180 sq.ft./hr. each. All the above plants are complete and in working order. Further details apply :—C. Dodman, Raleigh Industries Ltd., Nottingham.

FOR SALE—Parkinson & Cowan **INFRA-RED GAS FIRED DRYING OVEN,** Approx. Heating Area 18ft. long × 7′ 6″ high × 1′ 10″ between panels. Max. Gas Rate 3,000 cu. ft. hour. I.C.I. CFD/5/59 Vapour type **TRICHLORETHYLENE DEGREASING PLANT,** 25′ × 2″ × 8″ deep. Gas heating at 1,350 Cu. ft. hour at 2″ W.G. Further particulars from: The Crittal Mfg Co. Ltd., Manor Works, Braintree.



Sole distributors in the United Kingdom of "High-Speed" Tin Anodes



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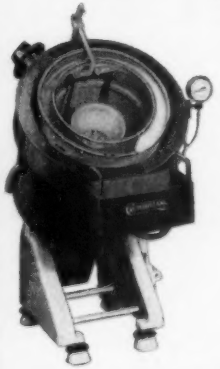

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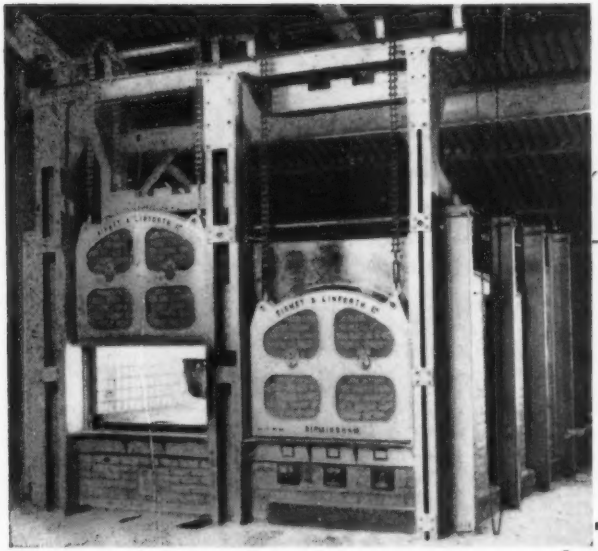

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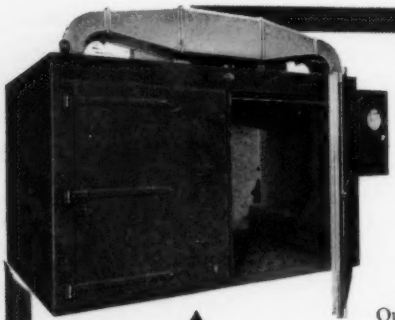

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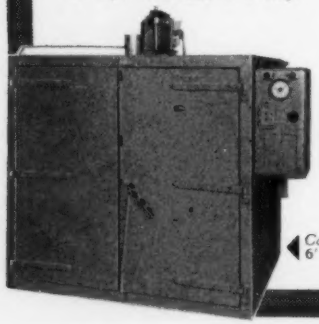

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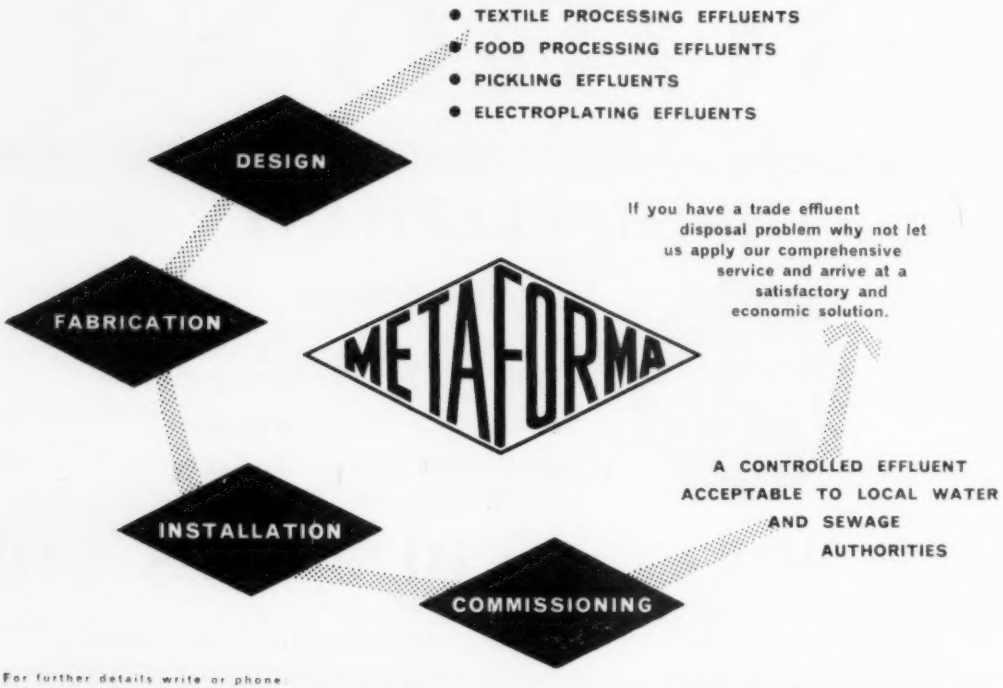
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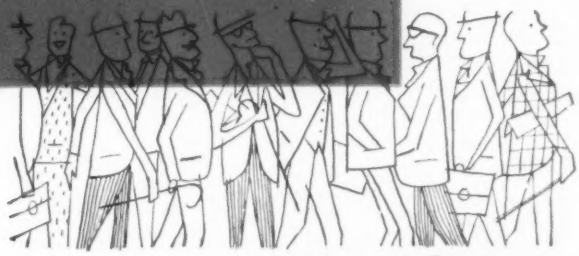

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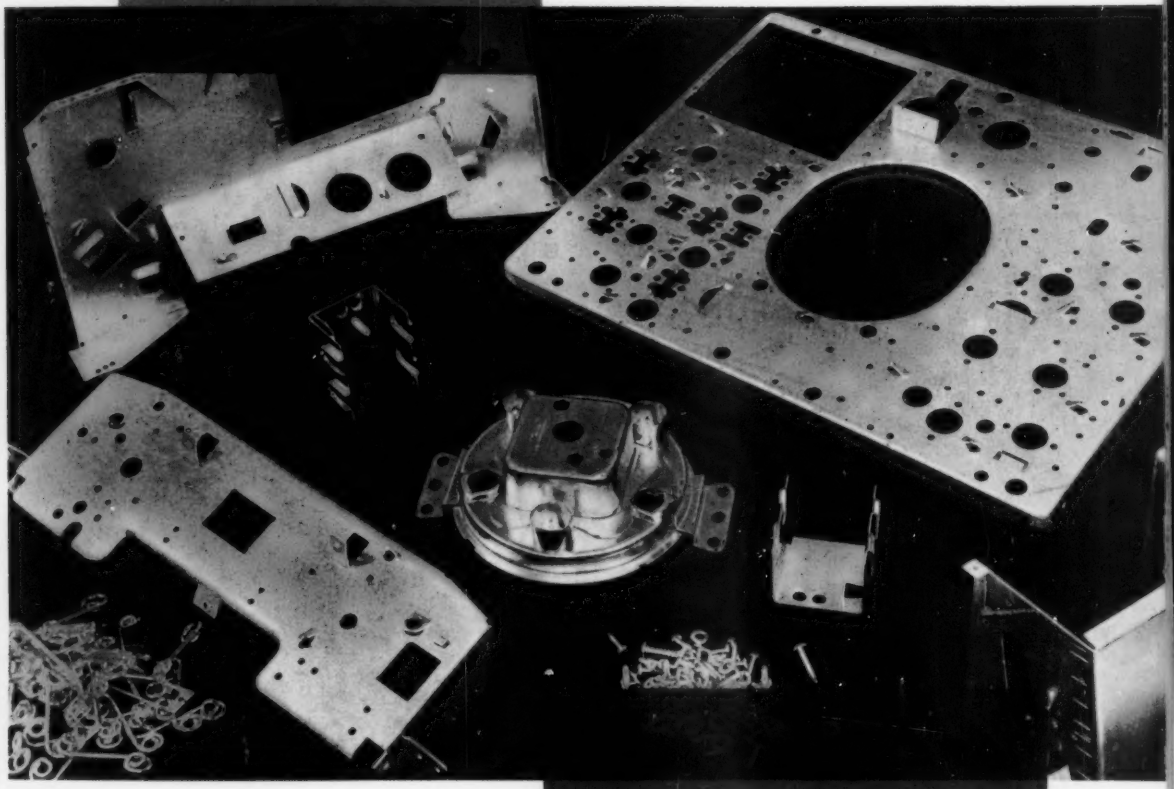

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